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PAPERS READ.

(VII.)
GASHOLDER-TANKS: DIFFICULTIES AND MISTAKES IN THEIR CONSTRUCTION.

By Mr. GEORGE LIVESEY, of London.

The object of this paper is not an ambitious one, though it deals with perhaps the most important of purely engineering works with which we have to do. It is, however, simply an account of some of the difficulties that have been met with, and the mistakes that have been made, in the experience of the writer.

In 1857 a tank 112 feet diameter and 25 feet deep was constructed in a dock or basin of the Surrey Canal in the Old Kent Road. This dock was a square piece of water, a trifle larger than the tank, in full communication with the canal. The contractor began his work by forming a dam consisting of two rows of short piles, with a space between filled with clay, to cut off the dock from the canal, the water being about 6 feet deep. He then excavated the tank in the usual way, supporting the trench with timber struts, whalings, and runners, the latter being 9-inch deals pitched closed together. The soil consisted of gravel and sand full of water; but ample pumping power being provided, all went well until the puddle under the wall, together with the footings and about a foot in height of the wall itself, were got in. When the time came to draw the runners, which process in such a loose soil necessarily results in a small portion falling in from behind them to fill up the space which they occupied (there is no harm in this in ordinary circumstances, as the only result is a slight settlement of the surrounding ground); but they were drawn at that part of the tank nearest to the dam, which was only about 6 or 8 feet distant, this very slight settlement was sufficient to disturb the dam, and about eight o'clock one evening the timber began to move, then to crack ominously, and in less than five minutes the tank was once more converted into a dock full of water, the dam being entirely swept away. The rush of water from the canal made a hole so deep that the next dam had to be made with whole timber piles 30 feet long. This disaster would certainly not have happened had the contractor left in the runners at the back of the tank wall for a distance of about 30 feet at the point where the tank was close to the dam, and thus the attempt to save about £10 worth of timber involved a loss of from £2000 to £3000.

This tank, after being successfully completed and at work for some four or five years, again came to grief, in consequence of the construction of the main sewer in the adjoining road. The sump for draining the ground tapped a stratum of fine sand which underlies the gravel on which the foundation of the tank was laid. This sand was pumped up with the water in large quantities, and being drawn from under the tank the puddled bottom gave way, and caused so great a leak that the tank had to be emptied, and repaired at great expense and trouble; but it was never again made perfectly sound. There is always this danger when a tank having sand full of water below its foundation, has another and deeper excavation made in its near neighbourhood.

In 1862 another tank was built, 112 feet diameter and 30 feet deep. In this case two mistakes were made. In the first place, the trench was set out of smaller diameter by 2 feet than the footings required, intending to cut away the earth—which was sand and gravel full of water—under and behind the bottom row of runners, in order to make room for the footings. This could not be done, and as a consequence the puddle at the back of the wall at the bottom was reduced to only 1 foot in thickness, which probably accounts for some of the leakage that for a long time took place in this tank. The other mistake in carrying out the work was the failure to sink the sump deep enough, and to provide sufficient pumping power. Had the sump been 3 feet deeper, it would have been in the chalk, and the pumps would have had to deal with clear water. Instead of this the suctions were in a bed of running sand, and, as a consequence, an immense quantity of sand was brought up, resulting in the falling-in of the bottom of a small adjoining tank, in the cracking and settlement of the wall of a large coal store, in the creation of great cavities in the earth in various directions, one being in a garden from 80 to 100 yards from the sump, and another in a public roadway about 40 yards distant. This last was made known by the weight of a passing cart breaking the crust of the road, when the cart dropped in, fortunately without any serious consequences, beyond frightening the contractor and the directors of the Company, and causing the excavation for the tank to stop 5 feet short of the proper depth, which brought the tank 5 feet higher than was intended. From the comparative shallowness of the sump and the deficiency of pumping power, the excavation was never properly cleared from water. Puddle was therefore put in under very unfavourable conditions. The tank could not be made tight; but it has been emptied two or three times for the purpose of trying to stop the leaks, and on the last occasion, in 1872, ten years after it was constructed, the leakage was reduced to a mere trifle, at which it has stood ever since. When this tank was made, the nature of the ground beyond 30 feet in depth was unknown. Had a boring been put down, the chalk would have been discovered a few feet lower, and some at least of these difficulties would have been avoided.

In the case of the next tank, constructed in 1867, this precaution was taken. The tank is 35 feet deep, and the sump, with ample pumping power in duplicate, was carried well into the chalk. The work was done to time—whereas the two tanks previously mentioned were a year behind—and when filled with water was quite sound. After a short time, however, a leakage took place. A diver went down to examine the puddled bottom, and he found in the puddle a clear round hole, into which he could thrust his arm. This he filled with lumps of clay rolled up in coarse canvas, which were well rammed into the hole, and the tank from that day to this has remained perfectly tight. How the hole was caused is not clearly known. It was not supposed to be made by a pole being thrust into the clay, or the falling of a crow-bar or a "dolly," but rather by the pressure of the water itself finding a weak place and making its way through. That 25-feet head of water can do this in puddled tanks has been fully proved by more recent experience, conclusive evidence in the next case having shown that holes, in form and appearance like rat-holes, have been made in this way.

The next case is a tank of brickwork and puddle, like those already referred to, begun in 1869, of 100 feet diameter by 30 feet deep. It is in a rather loose sandstone

rock with numerous joints and fissures, but containing very little water. The whole interior of the tank was excavated, and there being no necessity for timber framing to support the sides, it appeared a very simple piece of work. The puddle on which the wall was to stand was put in, the wall was built and backed with puddle 2 feet thick, the space between the back of the puddle and the face of the excavation being filled in with material consisting of pieces of sandstone rock, sand, and earth from the excavation. The bottom of the tank was excavated to a slope of 4 to 1, the fissures filled up with pieces of rock and sand from the excavation, and the whole covered with puddle. The work was apparently finished satisfactorily, and the gasholder erected. Water was put into the tank with the intention of bringing the gasholder at once into use; but when nearly filled a leakage occurred. On taking out the water some weak places were found in the puddle at the foot of the wall; these were stopped, and another attempt was made to fill the tank, which failed as the first had done. This process was three times repeated, and always with the same result, until the Company took the work out of the hands of the local contractor, and employed another of very large experience in this class of work—one who had sent in a tender in the first instance, but, being somewhat higher than that of the local man, it had not been accepted. The puddle under the wall, for a distance of 18 inches from the face, was, after several vain attempts to stop the leakage, all taken out and replaced with new puddle of the best kind, but in vain. The water always forced a passage through it. When success seemed nearly on the point of being attained, the puddle on the cone in the interior of the tank gave way; the clay was forced into the fissures that had been filled with stones and sand, and the water consequently made its way through in these places. Eleven times, in addition to the three above mentioned, was this tank tested. It would stand until within a foot or in some cases 6 inches of being full, and then all at once it would begin to leak. The pressure of the water forced—one might almost say punched—through the puddle over one or other of the before-named fissures a round hole large enough to receive a man's arm. One such hole only was usually made, because directly the water found vent the pressure on the top of the puddle was neutralized by an equilibrium, to some extent, being established. At last the bottom was made sound by removing all the puddle—the inner lift of the gasholder was in the tank during the whole 18 months—as far under the wall as possible, and all over the cone, which was then concreted, and on this thoroughly sound bottom the puddle was laid for the last time. The pressure of the water had no further effect upon it, and henceforth the bottom was sound. Then a leakage took place through the wall; the puddle at the back of the wall being forced into the backing. The bottom of the tank over the puddle near the wall was therefore concreted and rendered, and the wall itself was also rendered; but even then, on filling the tank, there was still a considerable leakage, which took place through cracks in the wall and rendering; a rendered tank, be it remembered, throws a strain on the wall which is entirely absent in an ordinary tank. The ordinary tank wall is pervious to water; the pressure of the water is, therefore, on the puddle backing; in a rendered tank, on the contrary, the pressure is on the face of the tank; and although this is counteracted by the backing of earth, it is extremely difficult to make filled-in earth absolutely solid. When the pressure comes upon it there will be, unless extraordinary precautions be taken, a slight giving way, and the wall will crack slightly, but quite sufficiently to cause disagreeable leakage, and this allowing the water to find its way to the back of the wall, the pressure on the face is counterbalanced, and the cracks do not extend farther. This is what took place with the tank in question. Complete success was finally attained by the very able, painstaking, and persevering foreman in charge of the work—who, by the way, is now principal foreman at the South Metropolitan Gas-Works—going down in a diving dress, the tank being kept quite full of water, and caulking these cracks in the rendering with fine yarn and tallow. The tank was made tight, and has so remained to this day.

The writer cannot pass from the narrative referring to this tank without saying that throughout the whole of this exceedingly anxious and troublesome business, to which he was Engineer, the Gas Company, through their Manager and Secretary, acted in the kindest and most considerate manner, their confidence never being withdrawn, notwithstanding the heavy loss sustained. The original contractor's men worked early and late, and although a clerk of works was employed, it was afterwards discovered that some of the puddle in the bottom was put in by the men, who were not experienced in this class of work, in a hurried manner very early in the summer mornings, before either the foreman in charge or the clerk of the works had arrived. Whether this was the cause of the disaster or not, it is quite clear that if puddle is to resist great pressure it must have beneath and at the back of it a perfectly solid foundation. If puddle is used and the bottom is not solid, concrete is absolutely necessary. If this tank had to be erected with our present knowledge and experience, it would be one of the easiest and simplest possible. A mere excavation in the rock, lined with concrete about 18 inches thick and 9 inches on the bottom, and rendered, would make a perfect tank at probably half the cost of the old-fashioned brick and puddled tank.

The next case is one in which the writer was called upon to advise after a disaster resulting from the inexperience of the contractor. A large tank was constructed in the soft clay or ooze near the mouth of a river, this clay being of the consistence of ordinary clay puddle, and of great depth. There was no fault to be found with the design of the tank, the wall was of sufficient thickness, and was built of concrete, and suitable footings were specified and shown on the drawing. With the soft foundation good broad footings were especially necessary; but the contractor actually built the wall without any footings whatever, the bottom of the wall being about 4 feet thick. It was his intention to put in sham footings after the interior was excavated; and at the back of the wall the absence of footings was compensated for by a set-off the wrong way at the height of 5 or 6 feet, where the thickness of the wall was considerably increased, and higher up another set-off was made, thus further increasing the thickness of the wall at the back. When the wall had been carried up about 15 feet all round, the interior was excavated, and another incredible mistake was made. The contractor attempted to make the excavation complete all round before beginning to put in the footings and the concrete bottom. Had he done this work in short lengths, the so-called footings and the concrete bottom would at least have strengthened the toe of the wall, and have better enabled it to resist the pressure behind it. The wall, which, being made of blast-furnace slag, was a fine piece of concrete work, stood without any support until two-thirds of it was exposed, when one night, after the men had left the work, it succumbed to the pressure, and the whole of the unsupported part gave way, and was forced forward into the tank to the extent, in the worst place, of some 6 feet. Though much broken, the wall fairly maintained the upright position, thus so far facilitating the construction of a somewhat smaller tank within the original, which has been successfully completed.

The last case to be mentioned relates to a disaster that happened last year to a cast-iron tank, about 60 feet in diameter, standing some 20 feet above ground. The plates were rather thin, but quite strong enough if the tank had been properly hooped. The hoops were composed of bars of flat iron, $\frac{1}{2}$-inch and $\frac{5}{8}$-inch thick, varying in width from 4 to 5 inches. There was a clause in the specification expressly providing that all joints in these bands should be of greater section than the band itself; and at the three forged joints in each band this stipulation was fully complied with, but there were other joints. The hoops were made up of simple bars of iron about 12 feet or 15 feet long, which were butted together and secured by a cover strip, of the same section as the band, by means of bolts only. Four $\frac{7}{8}$-inch holes were punched in these bars of flat iron to receive the $\frac{3}{4}$-inch bolts. These holes were in couples and in line, and had the effect of cutting out $1\frac{3}{4}$ inches from the width of the band, thus reducing a 4-inch band to $2\frac{1}{4}$ inches, and one 5 inches wide to about 3 inches. A short time after the tank was filled with water the hoops gave way, and the whole of the tank above the level of the ground was thrown down. The hoops were light, certainly, but would have stood had their full section been maintained. This, however, being by the punched bolt-holes reduced by about one-half, failure was inevitable. The contractor, to his credit, undertook to restore the work, and has no doubt taken care that the hoops shall be strong enough to sustain the whole pressure of the water, without depending at all on the cast-iron plates, which should be regarded as if they were so many staves of a cask held together entirely by the hoops.

If this record of some of the difficulties and mistakes in tank construction which have come within the writer's experience should be the means of saving some of his brethren from similar anxieties, he will feel that the paper has not been read in vain.

Discussion.

Mr. R. MORTON (London) said he did not think there was much to discuss in this paper. They were very much obliged

to Mr. Livesey for having pointed out certain errors in tank construction; and it was for them all to think well over the subject, and endeavour not to repeat them when making tanks themselves.

Mr. W. Foulis (Glasgow) asked Mr. Livesey what was the width of the fissures in the tank.

Mr. Livesey said they were not very great; but in places pieces of the rock were torn out by blasting, and instead of being filled in with concrete they were filled in with fragments and sand.

Mr. Foulis said there was one important thing to note. Mr. Livesey had pointed out that a puddle tank built with brick or concrete depended on the puddle for soundness, and the weight of water was thrown on the inside of the puddle. This showed the great necessity in puddle tanks of ramming the earth hard outside the puddle; as, if this were not done, however well the tank might be built, it would not be water-tight.

Mr. W. J. Warner (South Shields) said the only remark he had to make was that these instances showed the necessity of boring to see really what base the superstructure had to rest upon.

Mr. H. Woodall (Leeds) said extraordinary as it might appear to build a wall upside down, as was the case in one of the illustrations given, something almost analogous to it was not unfrequently done until late years. At Leeds there were a number of gasholder-tanks, the piers of which only started half up the depth of the tank instead of being built from the bottom. The effect of this had been that in three holders, having 36 columns, not less than 50 per cent. of them were broken. In one case, out of 12 columns, only 2 of them were sound, so that the holders were now dependent on about six ¾-inch bolts to each column. As a matter of course, all the framing of the holder would have to be pulled out, and wrought iron substituted for it, on account of this very stupid error.

Mr. R. O. Paterson (Cheltenham) said he had been much struck with one remark in the paper, where Mr. Livesey said it should be remembered that a tank rendered with a coating of cement must have a strength in the wall sufficient in itself to resist the pressure of the water inside. He would grant this; but if it were a tank built without puddle, did not that militate against the theory of dispensing with puddle? because if the stability or tightness of a tank built with a rendering of cement on the face of it, and having no puddle behind, depended on the stability and strength of the wall, was it not, as matter of ordinary precaution, advisable to put puddle behind it?

Mr. S. Rutter (Brampton) asked Mr. Livesey whether, in the 1862 tank, with a little gasholder by the side of it, there was not some 5 feet of water left in the small tank?

Mr. Livesey said that was so.

Mr. Rutter said that a tank his Company made was built in the chalk without any puddle; though tanks in the North were generally built with puddle. His were built in brick-work, and then rendered over with cement, and they were quite sound without puddle.

Mr. C. Gandon (Sydenham) thought Mr. Livesey could hardly have meant that the walls of a cemented tank ought to be built sufficiently thick to support the pressure of the water inside it, supposing they were unsupported by the weight of the backing. The earth backing in the tank without puddle had the same duty to perform as with puddle; the only difference being that the pressure of the water was all inside the tank in one case, whereas it passed through the wall in the other, and was exerted on the puddle. If the earth were well rammed in behind the tank, even without puddle, it would perform a considerable office in resisting the pressure of the water.

Mr. Paterson said he feared he had not made himself quite understood. Having a puddle backing there was a yielding surface which, if the wall did open a bit, would be sufficiently elastic to enable it to give without opening sufficiently for the water to pass through; but, in the case of a concrete or brick-built tank rendered with cement, one crack was fatal to the tightness of the tank.

Mr. Corbet Woodall (London) said he did not think it was to be regretted that the experience of many of those present did not enable them to cap the illustrations Mr. Livesey had given, and to recount more examples of things to be avoided. He was struck with the point to which Mr. Paterson had drawn attention—whether, a tank being rendered, its soundness was dependent on the rendering, or whether, backed by puddle in each case, the putting in of backing behind was of equal importance. The pressure of the water came to the backing in either case, and in either case it should be attended to most carefully. One other point which also struck him was the reference made to a practice too common, of making the excavation too small for the footings. He had known many cases where the contractor had done his utmost to leave the trench as much smaller as the footing represented, in order that at the end he might undercut the backing, and put the footing in that way. A more objectionable practice could hardly be, whatever the character of the ground in which the work was carried out. A further point was as to the withdrawal of the runners. Mr. Livesey said that when they were withdrawn there was a space left behind, which was sometimes not filled in, and which was liable to leave weak places behind the wall. But this need not be the case if proper care were used. The runners should only be withdrawn very gradually and as the backing was put in. The operation should be carefully watched. On the other hand, it was very undesirable to leave either runners, poling boards, or anything else, in the excavation, if it could be avoided. He was amused at the illustration his brother had furnished of what might be done in the matter of framing. It hardly came into the discussion on this paper, but if it was found that a not too strong gasholder framing with 12 columns, 10 of which were broken, would stand, did it not suggest rather wild ideas as to what might be done in the way of very light framing?

Mr. Morton said the trenches ought to be wide enough on the inside to do everything required; but in the case of excavating in clay, for instance, where there was to be a puddle tank with a concrete wall, he thought the outer diameter of the trench ought to be exactly the outer diameter of the wall, and there was no objection whatever to carefully cutting a toe in the solid clay about 18 inches or 2 feet, to give a base to the wall. It was much better than cutting the trench out all that much larger, at an extra expense, and the risk of not getting the backing in perfectly solid at the lowest part, where the greatest pressure was. With regard to Mr. Henry Woodall's mention of the walls being made with the piers carried up as off-sets, he did not know that it was very objectionable if done with care. At the present moment he was constructing a concrete tank, the wall of which at the bottom was 5 feet thick. The trench was excavated to the exact size, filled in with solid concrete in the clay, and the piers for the standards were 6 ft. 6 in. wide, which was a projection of 18 inches from the 5 feet. He did not anticipate that the slightest harm would come to the tank from so doing.

Mr. G. B. Irons (Gosport) desired to thank Mr. Livesey for having given the members of the Association the benefit of the mistakes he had described. As to the question of the withdrawal of the runners and the width of the excavation, he (Mr. Irons) thought that the engineer of the works should always maintain absolute control over the whole proceedings of the contractor, so that he might be able to cause him to excavate to whatever width he thought necessary, and to withdraw the runners gradually or leave them in; though no doubt it was very objectionable to leave timber in the ground where it might rot, and subsequently cause subsidence of the soil. He should like to know what particular kind of clay was used, as a great deal depended on the quality of the clay employed.

Mr. Corbet Woodall wished to add a word of explanation, as he did not think Mr. Morton quite followed his point. He was only referring to putting in the backing. He was at the present time constructing a tank where he really followed Mr. Morton's advice. At the Kennington Lane Gas-Works the outer diameter of the trench was the outer diameter of the wall; but where backing was to be put in, it was there, in his opinion, that it was advisable to dig the trench out the whole width of the outside of the footings of the puddle.

Mr. Warner said his practice had been the same as Mr. Morton's. He only excavated to the outside of the outer wall, and then cut away for the footings.

Mr. Livesey, in reply to the remarks that had been made, said, with regard to rendered tanks, the tank he first constructed at the South Metropolitan Gas-Works, which had no clay puddle at all, had cracked in five or six places. He attributed this to the earth backing; for, although it was put in as solidly as possible, still it yielded sufficiently to allow the tank to open to a very slight extent. In the tank just built they had put in a number of iron bands 3½ inches by ½-inch, the wall was rather thicker, and great attention had been paid to the backing; and he had good hope that it would not give way at all. The concrete was filled in solid to the height of 20 feet, to avoid the necessity of backing. In this he agreed with Mr. Morton. He also agreed with him that it was best to cut under for the footings, where it could be done, as in the London clay, but certainly not in sand or

gravel. In his own case, on chalk, no footings were required, the chalk being perfectly solid. Mr. Rutter's remark about tanks in chalk was quite correct. In chalk or rock there was something solid, and all that had to be done was to make the excavation, put in the concrete up to the chalk, and render it. The chalk could not give way. With regard to the puddle backing, it should be remembered that if there was puddle behind the tank wall it was not, perhaps, so important to fill in the backing in quite so solid a manner, because the puddle itself was a semi-fluid, and its own weight and pressure would close up cavities. The spaces behind the runners, as Mr. Woodall had said, ought to be filled up, but where there were runners in something like solid clay, it stood when they were withdrawn. But the tank he first referred to, where the great disaster happened, was in loose gravel, and the instant the runners were withdrawn the gravel fell in. The clay in the Old Kent Road was the best he had ever seen—the Peckham clay; not the blue London clay, but very strong yellow clay. Where they had to build tanks in the London or other clay, he should say let them be puddled; but where they had to purchase the puddle, reckoning the expense of it in the first instance, and the trouble involved in putting it in, and the risk of its not being sound at last, there was quite sufficient to decide him to do without it.

The PRESIDENT said they would all agree that the paper Mr. Livesey had read was one of the most valuable contributions the Association had ever had. It was said that people learnt more from failure than success. As Mr. Morton had remarked, it was for the members to take such lessons to heart, and avoid the disasters that had been pointed out, which arose in some cases from mismanagement, and in others from unfortunate circumstances.

(VIII.)

A NEW ARRANGEMENT FOR CONDENSATION, AND PREVENTING OSCILLATION CAUSED BY THE EXHAUSTER.

By Mr. J. SOMERVILLE, of London.

A quarter of a century ago it was thought quite right to prolong the contact of the gas with the tar from the point of distillation to the end of the condenser, or until the gas had attained the same temperature as that of the atmosphere. It was also thought that the gas absorbed a portion of the lighter or more volatile hydrocarbons contained in the tar, and so added to its illuminating power. Probably this *was* the result of the contact for the first quarter of the time; but for the rest, or after the temperature went down to about 90° Fahr., the heavier portions of the tar re-absorbed the light-giving constituents of the gas.

In more recent practice the tar has been taken off as soon as possible after leaving the hydraulic main, allowing only the gas and ammoniacal liquor to travel together; thus preventing the tar from having any influence on the gas, but allowing the liquor, flowing in contact with the gas, to absorb a percentage of the sulphur compounds, consequently reducing the amount of lime generally used. Modern arrangements have been proposed to allow the tar to fall into a separate vessel near the hydraulic main, and, by means of heat, to vapourize the most volatile of the hydrocarbons, and allow these vapours to pass along with the gas, while the heavier portion of the tar runs off to the tar-well.

While this complication of apparatus and the necessarily increased attention required in the carbonizing department are undesirable, there can be no doubt about the advantages of separating the tar from the gas as soon as practicable, for it is now well known that the cold tar has a very destructive influence on the olefiant series, or light-giving constituents of the gas, and that it is well to separate the lighter from the heavier tars; that is to say, as soon as possible remove the tars having a density—according to the admirable table of the late Dr. Letheby—of over ·900 specific gravity, and a boiling-point of 180° Fahr., and allow the lighter vapours below ·900 specific gravity, and a boiling-point as low as 130° Fahr., to pass with the gas. The lighter hydrocarbon vapours give up their illuminating properties, and so enrich the gas by prolonged contact with it.

The object of this paper is to describe a new, simple, yet effectual arrangement for this purpose designed by Mr. Livesey, and erected last year at the Old Kent Road works of the South Metropolitan Gas Company. The arrangement is shown in transverse section in the accompanying engraving (Fig. 1), where, as the gas issues from the retorts, it passes up the ascension and bridge pipes, but instead of entering a hydraulic main by a dip-pipe, as in the usual manner, it still further ascends by a second ascension-pipe, while the heavy

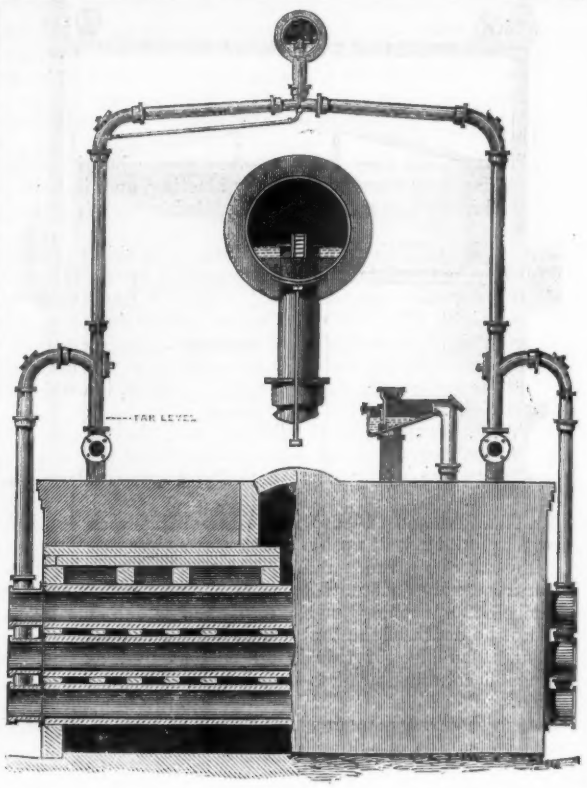

FIG. 1.

tar, from the point where condensation commences—viz., the turn of the bridge-pipe—is received into a 6-inch pipe, which occupies the usual place of the hydraulic main. This tar-pipe also receives the heavy tar from the second ascension-pipe, and each pipe being sealed about 6 inches prevents the gas passing from one retort to another. The tar flows off to the tank, while the gas goes on to a receiving main, and the ascension-pipes uniting in the centre, enter this main at the bottom by a 4-inch pipe. The receiving main is made of light wrought iron, in convenient lengths, 18 inches in diameter, and is continuous throughout the length of the retort-house. The 4-inch pipes from each retort project 4 inches into it, and are each fitted with a light faced valve, balanced on the turned edge of the pipe, and kept in place by a forked bolt, through which the tail of the valve passes, thus dispensing with hinges or spindles, which are liable to clog. The valve has a rim 1 inch deep, which, when closed, dips ¾ inch into the liquor contained in the main, and ensures a perfect seal, while the retorts are being charged. A by-pass throttle-valve, actuated by a small gasholder, is provided to regulate the vacuum in the receiving main. This is found indispensable when working with and without dip-pipes. The gas and ammoniacal liquor pass together along this main, descending by the foul main to the condenser. To ensure that an inch of ammoniacal liquor shall always separate the tar from the gas in the receiving main, an overflow-pipe is provided every 10 feet, by which the tar is drawn off from the bottom into the tar-main. We have thus an arrangement of fractional condensation. The temperature at the bridge-pipe being about 150° Fahr., half way up the second ascension pipe it is 130° Fahr., half way along the horizontal pipe it is 110° Fahr., and on the top of the receiving main it is from 92° Fahr. to 95° Fahr.; at the inlet to the condenser it is 80° Fahr., and at the outlet the gas is the same temperature as the atmosphere. The tar collected in the 6-inch tar-main has a specific gravity of 1·275, and that in the receiving main 1·150, or 1¼ lbs. per gallon lighter.

In connection with the condenser is a balanced gasholder, situated between the outlet of the condenser and the inlet of the exhauster, to prevent the oscillation caused by the exhauster from affecting the retorts, and at the same time providing a large chamber for the repose of the gas, so that it may further deposit any tarry matter, which it does to a considerable extent. The illustration (Fig. 2) of this balanced and compensating gasholder (drawn partly in section and partly in elevation) shows the arrangement. It is an annular wrought-iron tank 30 feet in diameter and 15 feet deep, erected over a concrete tank 30 feet in diameter and 15 feet deep, sunk in the ground, and both divided into two compartments, the lower one by a concrete wall, and the annular one

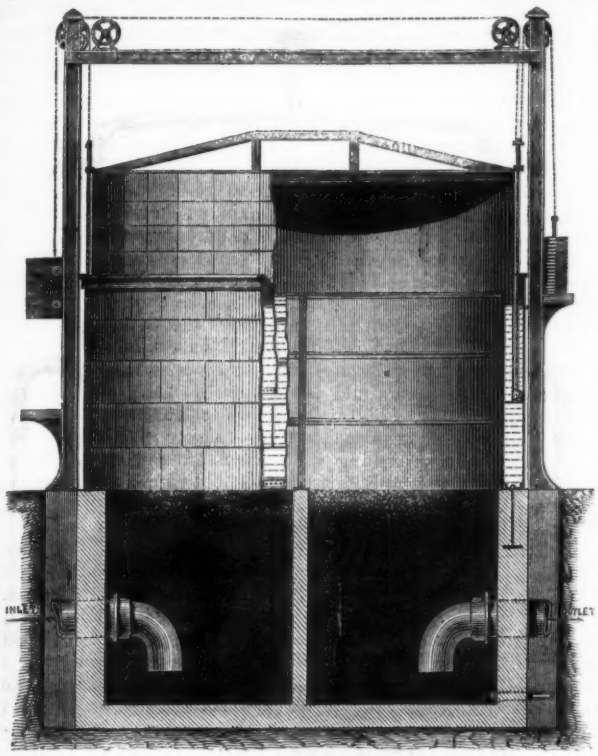

FIG. 2.

by a sheet-iron division-plate or diaphragm; the height of the iron tank making two chambers, each 30 feet high, and an area of 350 square feet. The gas entering at the bottom from the outlet of the condenser, through a 30-inch main, equal to an area of 5 square feet, slowly ascends, and passing over the division-plate, descends to the bottom of the second chamber, and makes its exit through a 30-inch main to the exhauster. We have thus a very complete arrangement for condensation.

The balanced gasholder works freely in the annular tank, its normal position being adjusted about half way. The adjusting weight is a tank of water, which may be added to or drawn off, thus allowing of the greatest facility in regulating the required vacuum; and when a number of retorts are slacked out at one time, the holder compensates at once for the difference, until the exhauster governor feels it, and reduces or increases speed, thus preventing the usual racing. Should the exhauster break down or stop from any cause, the holder slowly rises, maintaining the vacuum for about 9 minutes, thus allowing sufficient time for a man to open any valves, &c. When the holder reaches the stops against the top girders, the balance-weights ground at the same time; the pressure then increases up to 18 inches, when it blows at the bottom, thus preventing undue pressure on the retorts, and acting as a safety-valve. When the exhauster is again started, the holder slowly descends to its normal position of half way in the tank.

It is found by this arrangement that no oscillation takes place beyond that which is due to the dips in the hydraulic main. The holder absorbing and compensating for the action of the exhauster, allows of a free flow of gas from the retorts without the usual fluctuating pressure and periods of pulsation, which go far to cause the formation of carbon on the retorts, and other disadvantages.

The apparatus has not been sufficiently long in operation to allow of any authoritative statement of results to be obtained, or any comparisons to be made of the benefits derived from its use, beyond the fact that oscillation is prevented, and that there is an increased condensing power obtained, both for tar and ammoniacal liquor. The liquor taken from the large chambers of the tank is 30 oz. strength, and has a specific gravity of 1·075.

I trust that my brief description of this new arrangement may prove of interest to the members of the Association, and that the benefits derived from its use may be appreciated.

Discussion.

Mr. G. E. STEVENSON (Peterborough) said that at the commencement of the paper Mr. Somerville stated that the contact of tar with gas prolonged in the foul main or condenser tended to absorb gases of the olefiant series; but it seemed to him there must be a mistake here. It would no doubt absorb the lighter vapours of the benzole series, but he should like to know the opinion of some one better acquainted with the subject than himself as to the question of the olefiant gas, which it seemed to him could hardly be absorbed at all by the tar. In the distillation of tar they did not find any gases of that series developed.

Mr. J. ELDRIDGE (Richmond) asked if there were any check against stopped pipes.

Mr. S. HUNTER (Salford) said there were certain subjects uppermost in the minds of gas managers, as mentioned in the President's Inaugural Address, and one of these was no doubt this very subject of condensing and carburetting gas. It appeared to him (Mr. Hunter) that if they went fully into the merits of the paper just read, they would introduce a great deal of matter which might be interesting to them for some hours to come, because it evidently bore on a great many things recently introduced to their notice, of which perhaps the most important was the analyzing process of Aitken and Young. It seemed to him that on some points they were agreed, but that on others they were in considerable doubt, and there remained matters for further investigation. If it were possible for them to carry the analysis of their own minds to the extent they did some of the mechanical contrivances, they might be able to separate the points on which they were agreed from those which required further consideration. If he gathered aright the tone of the meeting, and the tone which prevailed in the correspondence and articles in the JOURNAL during the past few months, they were agreed that there was a point at which the tar liquor and gas ought to be separated, but the doubt was at what temperature this separation was to be effected. Mr. Somerville had introduced Mr. Livesey's mode, and it indicated the temperature at which gas was taken away from the retorts and the point at which it was separated from the tar liquor, as well as the process of doing it. He thought the principle was pretty much the same that was followed in other modes he had been referring to; but one point which struck him—a point which had been put foremost in the articles in the JOURNAL, written by Mr. R. H. Patterson—was the separation of the heavy oils and "sooty" or carbonaceous matter from the gas. If he understood this process aright, one object in view was the separation of what Scotchmen called the "soot" and the heavy oils from the gas. Until this was settled there was a certain point of weakness in these processes, and he did not clearly gather that in the arrangement shown there was any mode of bringing about this end. It appeared to him that it was an admirable arrangement for separating liquid matter from the gas, but did not go beyond this, and did not seem to effect the separation of the tarry or "sooty" matter which was suspended in the gas. They certainly wanted a method for preventing oscillation on the exhaust, but the plan suggested was not one they could all adopt. All managers could not put down a 30 feet by 15 feet holder; but wherever it could be adopted, if the exhauster could have a mass of gas like that to pull from, there must be a great equalization in the exhaust. In his own works he had adopted an arrangement which, though not efficient, had the same object in view. He had put down a large cylinder, and thus allowed the exhausters to pull from a very large volume of gas. The apparatus shown by Mr. Somerville went beyond this, because it was capable of movement under varying conditions, and this no doubt reduced the oscillation to a minimum. They still required, however, a more perfect separation of the heavy oily or tarry matters from the gas. He understood Pelouze and Audouin's patent to be designed for this purpose; but the Aitken and Young process was better still, for it not only separated the heavy oils, but presented to the gas the light oils, which, when the heavier ones were removed, the gas was more capable of retaining. As this was evidently a matter uppermost in all their minds, it was possible that by their next annual gathering he might be able to detail some actual results.

Mr. D. B. PEEBLES (Edinburgh) said he should like to know whether there was any lessening of the deposit of carbon in the retorts since this plan was adopted. He asked this because some years ago, at Alloa, a Mr. Boyd adopted the plan of taking away the seal from the dip-pipes in the hydraulic main, and worked with some of his retorts unsealed and others with a seal. He then found that the oscillation produced by the ebullition of the gas through the watery tar in these retorts gave very much more carbon deposit than in the other ones. He mentioned this to Mr. Young, and he immediately, in the usually quick, ready way with which he laid hold of any new theory, went home, and in a small experimental apparatus produced oscillation which

led to a deposit of carbon in very large quantities. The appliance described in the paper seemed the first practical method of entirely taking away this oscillation, and he should like to know whether there had been any lessened deposit of carbon in the retorts in consequence.

Mr. Frank Livesey (London) said he might give a little further explanation on the subject. There was a small main running on the top of the retort-benches, and connected with the two ascension-pipes shown in the drawing, and which received the very heavy and thick tars only—so heavy that it was somewhat difficult for them to flow. In the upper main was again collected tar which was thin and fluid, and floating upon this was always kept a certain quantity of liquor by the arrangement explained by Mr. Somerville. The plan was not thoroughly complete, because this thin tar, according to present ideas, should be exposed to some higher temperature, and what vapours could be obtained from it should be put into the gas. Still the arrangement was so far complete, and was capable of adaptation to further improvements. The thick tar which could be of no further use was taken away at once, and the thin tar could be conveyed into another main and subjected to heat, by means of steam or otherwise, and the vapours driven off into the gas.

Mr. W. Carr (Halifax) said this matter brought them face to face with the question of the contact of gas with tar; and the paper just read was a valuable contribution on the subject. But his object in rising was not so much to discuss the paper as to ask a question with reference to the lecture of the previous evening. He wished to know the specific gravity of the tar experimented upon in the series of experiments described by the lecturer, and by which the somewhat surprising results then detailed had been obtained. If Mr. Morton could give them this information, it would be a valuable addition to the discussion of the subject, and would add to the usefulness of the information laid before them the previous evening. With regard to the paper itself, he had the pleasure of going through the South Metropolitan Gas-Works a short time ago, and of seeing the apparatus just described; when the question struck him as to the stoppage of the ascension-pipes, because if they did stop at all they would be rather awkward pipes to clean out. He was very much troubled with the stopping of the ascension-pipes in his works, partly from the friable nature of the coal used, and the peculiar manner in which the gas came off in carbonizing. He was afraid that at Halifax with pipes like those they would have great difficulty in keeping them clear.

Mr. R. Morton (London) said it appeared by the drawing that there were two ascension-pipes to each retort, but he believed to a great extent this was being done away with. He should like to know whether the diagram was correct; and, if so, whether it was found that, the seal being done away with, the gas went up the two ascension-pipes in anything like equal proportion, or whether it went sometimes one way and sometimes another. With two ascension-pipes to each retort and a seal at each end, they often found the gas went up sometimes on one side and sometimes on the other. It was thought that this arose from a little inequality in the seals. The subject of the contact of gas with the tar was dealt with in this apparatus; but it appeared to him that in the large vessel there was considerable contact of the gas with the tar through the sides of the gasholder, which at this point was supposed to be cool, and might deteriorate the quality of the gas. Mr. Livesey had had these large cylinders in use without a compensating arrangement; but he (Mr. Morton) did not think they were put up with any idea of affording compensation to the oscillation of the exhauster, but to give the gas a rest on the way, and allow it to deposit some of the solid particles left in it. He did not think Mr. Hunter could have expected to find any difference in the oscillation by simply putting in the cylinder without a compensating arrangement, for he did not find that cylinders of any size between the retorts and the exhauster made any difference in this respect. As to Mr. Carr's question, he could not tell him the exact specific gravity of the tar; but what Mr. Greville Williams brought before them the previous evening was only part of a series of experiments he was conducting, which he hoped at some future time to be able to lay before the Association with all the details. He believed they would be very interesting, and would determine some of the points which were at present not very clear. What he had done as yet was simply to ascertain by an excessive contact of gas with tar what the difference in illuminating power of the former really was, and this was explained the previous evening as something like 2 candles. The tar used was simply taken from the store tank.

Mr. George Livesey said there was one point that Mr. Somerville had omitted. He should have said that this was a joint business—for his brother, Mr. Somerville, himself, and the foreman had all had to do with it. The question had been raised about the pipes stopping up. He might say that when they were working great heats, as they did with their new furnaces, the pipes stopped very much indeed, but the stoppage all took place in the ordinary position, below and at the first bend. The upright pipes above the arch-pipes did not stop at all. They were now going to try another plan of dealing with the tar. In the tar-main, as shown, the tar was so viscid that it would not flow at all freely; but the whole thing was experimental, and merely put forward for what it was worth. Their last idea was to put in place of the bridge-pipe a large pipe sloping downwards, with an opening at the bottom, connecting it with a trough for the tar. This would not be absolutely air-tight, but would be covered over with plates, so that in case the exhauster stopped at any time an outflow of the tar would be prevented. Mr. Morton was quite right. His (Mr. Livesey's) object in introducing the large 4-feet tubes was to have the thicker part of the tar deposited before reaching the exhauster, and the balanced gasholder was an amplification of the old idea.

Mr. W. Foulis (Glasgow) said there had been a great deal done in Scotland in carburetting gas, and the object had been to take away the heavy tars, which, no doubt, did dissolve the benzole vapours at such a temperature as would leave these vapours in the gas. But the great difficulty in his mind, and the great question to be considered, was, after the gas had been saturated with these vapours, was the gas perfect? On this point there was still a doubt left in his mind, for it seemed to him that it was more like charging atmospheric air with the heavy vapour, which was deposited on the first change of temperature. With regard to preventing oscillation in the retorts causing a small deposit of carbon, he tried a few experiments some time ago. They had two settings of seven retorts each working alongside of each other. In the one bench they had the ordinary dip-pipes, and in the other they had dip-pipes with small holes round about, in order to give the same average pressure, yet so as to prevent oscillation. They kept these two settings working for several months, and at the end of the time the retorts in each setting were in the same condition with regard to carbon; so that, whatever might be the cause of the deposit of carbon, he was inclined to think that oscillation or pulsation of the gas in the retorts had not a great deal to do with it.

Mr. R. Mitchell (Coatbridge) said he could confirm what had been said about oscillation. Two years ago he made experiments with reference to the dip-pipe, following the plan Mr. Foulis had mentioned, and the oscillation in the retorts was scarcely perceptible on the pressure-gauge, but he was still as much troubled with deposits of carbon as before.

Mr. Somerville, in reply, said he always thought it was the olefiant gases which afforded the light-giving properties to gas, and he found by experiments with the thick heavy tar Mr. Carr had mentioned, from the 6-inch main, that it was of a specific gravity of 1·275, or 12¾ lbs. The very heavy thick tar was taken off first, and in passing 16·5-candle gas through three washings of it, the gas was reduced to 12·5 candles. He had also experimented on it by passing gas through the tar collected in the receiving main, which had a specific gravity of 1·150, or 1¼ lbs. lighter, and it had no effect upon the light-giving constituents of the gas. The previous evening Mr. Greville Williams touched on a similar subject, and he (Mr. Somerville) should have liked to ask him what kind of tar he used, as he expected it was ordinary tar taken from the tar-well. He had an unfortunate experience in Dublin with reference to the carbonizing of the Mackenzie's mixtures of oils and tars, and he would advise his brother managers to be very cautious how they heated tars and then passed the gas through them. His experience was that although they passed the condenser and the station-meter, they separated, and would deposit again underground the hydrocarbons taken up, and would not carry them forward to the consumers burners. He had lost as much as from 3 to 4 candles in three-quarters of a mile of 36-inch main between the works and the testing-station with these oils, which were of similar specific gravity to the tar. As Mr. Livesey had explained, they were going step by step, and if they found by-and-by that the vapours were likely to add some light-giving property to the gas, it would be a very easy matter to arrange the apparatus for it. At present what they wanted to do was to get rid of what had been described as their "nasty, dirty, heavy tars," and keep them from coming into contact with good gas, as he was of the opinion that "evil communications corrupt good manners." They had had some stopped ascension-pipes, but not very many, and

not until they had generator furnaces. Then they had to get water-jackets, and tried several things, and were now putting up a little different arrangement. With regard to the compensating holder for reducing oscillation, the retorts they lighted up last year had not shown the slightest appearance of carbon on them, and had not been scurfed once. This was a different experience from that of Mr. Mitchell, and he could not understand how it was that that gentleman still had the same amount of carbon on his retorts after the oscillation was reduced. Mr. Morton said, "Would not the gas in the holder come in contact with the tar?" but he (Mr. Somerville) must remind him that it made all the difference what the specific gravity of the tar was. It did not matter about the tar of light specific gravity coming in contact with the gas. At the same time the tar in the holder was partly covered over with liquor which was nearly of the same specific gravity as the tar.

The PRESIDENT said it was very evident that the plan that had been described to them was a step in the right direction; but it was also apparent that more remained to be done. It had been pointed out by one speaker that what they had to aim at was to establish contact with the gas and tar under certain conditions of temperature, but also—which was of no small importance—to determine when this contact should cease, and to separate the heavier portions of the tar as soon as possible. This latter was partially effected by Mr. Livesey's arrangement, as proved by the specific gravity of the tar drawn from the first receiving main; but it was evident that the process required to be carried a little farther. Mr. Morton had pointed out the undesirability of contact as promoted in the balanced gasholder, when the tar was comparatively cool. Mr. Somerville had answered this by saying that contact with tar of such light specific gravity would not injure the gas. He (the President) thought, however, that the question most naturally arose, how was this tar made? Was it not by union of the heavy particles carried forward with the lighter naphthas, the presence of which, could it be secured, would materially enrich the gas? Their aim should be to promote the separation, at as high a temperature as possible, of as much as practicable of the heavy carbon particles of the tar. To a certain extent this was done by the arrangement before the meeting, but more remained to be effected.

(IX.)
STANDARDS FOR ESTIMATING ILLUMINATING POWER.

By Mr. F. W. HARTLEY, A.I.C.E., of London.

The subject to which I request your attention on this occasion is an old one, but one which is of as much importance and interest now as it ever was; indeed, it may be said to be now of greater importance than in the distant past, inasmuch as testings for illuminating power are more general throughout the kingdom, are made in a more stringent and more refined manner, and, if statutory obligations are not met, entail penalties, dissatisfaction among consumers, and bickerings between gas companies and corporate bodies; causing discomfort to directors, and more especially, perhaps, to their engineers and managers.

That the method by which the illuminating power of coal gas is ascertained should possess, as far as is possible, the characteristics of accuracy and of constancy in indication of values, no one will dispute, and that such should be the case is of the highest importance to gas companies, for so long as the method pursued is one which is liable to fluctuations, which sometimes cause the value of the gas to be under-estimated, and on occasions to be over-estimated, so long it will continue to be a necessity for companies to make gas of 1 or 1½-candles greater illuminating power than mere legal obligation requires. This necessity in many instances involves the use of a considerable percentage of cannel coal, which might probably be dispensed with if the tests were made under conditions of a more certain and absolute nature.

I do not wish it to be supposed for a moment that I am an advocate for the reduction of the illuminating power of coal gas to the lowest statutory limit in any case; for companies best serve their own interests as well as those of the public by supplying gas of the highest quality which is consistent with possibilities and the rights of the shareholders. It is usual to do so now; but this is very different from being compelled to supply gas of superior quality in order to overcome and neutralize the evils which might arise under the present uncertain state of matters.

The estimation of illuminating power can only, in my belief, be satisfactorily arrived at by visual, or photometric comparisons between the light of flames, one of which is adopted as a standard. Upon this point, Mr. Vernon Harcourt observed in a paper "On a New Unit of Light for Photometry," which he read before the Physical and Chemical Sections of the British Association in 1877, "that since the value of an illuminant depends solely upon such parts of the total force radiating from a flame as affect the human eye, no test of illuminating power can be satisfactory which does not depend upon vision; at least until it has been proved that some other effect of radiation . . is for all flames in direct proportion to the effect upon the optic nerve—a relation which seems very improbable, and which cannot be established until some exact mode of measuring the visual effect has first been found."

At the time when the foregoing extract was read, the radiometer was still attracting a good deal of attention, and some scientific men, accepting too readily the theory that with this instrument light was the sole operating force, jumped rather hastily to the conclusion that the radiometer was capable of being used for estimating illuminating power. As, however, the instruments were made more delicately, and especially as their chambers were more perfectly exhausted by the aid of the most improved form of the Sprengel pump, it became manifest that heat rays operated as powerfully as light rays in producing the rotation of the vanes. I have a radiometer which is so sensitive to heat rays that its vanes will revolve with considerable speed if the hands are placed round, but at an inch distance from the instrument. This rotation has been produced by the warmth from the hands, even when they have felt cold if applied to the face.

The selenium photometer also excited the attention of scientists for a time, but all interest in it seems to have died out. With this instrument an electrical current of regulated strength was caused to pass through a piece of crystallized selenium, which was shielded from light in a closed box. The current then traversed a reflecting galvanometer, which was so adjusted that under the conditions specified the spot of light produced by the reflection of a ray from a burner fell upon the zero of the scale. The box was then opened, and the selenium exposed for ten seconds to rays of light, which caused a diminution of the resistance offered by the selenium to the electric force and consequent motion of the galvanometer. The extent of motion or throw of the galvanometer appeared to be inversely proportionate to the distance of the source of light, or as the square root of the illuminating power, and therefore analogous to the indications of an ordinary photometer. This was a very interesting instrument, as it served for one thing to show that crystallized selenium was an exception to the well-known law of electrical science, that the power of an electrical conductor diminishes as its temperature increases.

The jet photometer and the durability test are both admirable instruments by which, with due care in using, to obtain approximate indications of illuminating power; but both fail, it appears to me, to satisfy the conditions which are essential in a standard test. Some reasons why they must so fail will be found in my observations on the jet photometer in the paper entitled "Remarks on Photometry" which I had the honour to read before the Association in 1870.

The visual determination of the relations in strength of light from flames which are contrasted with each other seems, then, to be the only method which can at present be deemed satisfactory, and in order that results may be expressed in terms which may be generally understood, a standard is required. As you are all aware, the sperm candle burning (nominally) at the rate of 120 grains of sperm per hour has long been, and is now, the photometric standard in this country as well as in some others. This standard has been tolerably well denounced, and, to a certain extent, deservedly so, for it is uncertain in value, as the light it affords varies greatly under conditions which appear identical, and with the slightest disturbance of the surrounding atmosphere, while its lighting power bears no known ratio to the rate at which the sperm is consumed. Nevertheless, and with full experience on the matter, I have spoken and written in favour of the sperm candle as a standard; and although I shall presently bring something under your notice which appears to be greatly superior, I am not prepared to propose the immediate abolition of the candle standard. It will be needful to retain the candle for some time, certainly until scientific men and Parliament are satisfied as to the constancy and convenience of any proposed substitute. The candle standard is a troublesome one, because, unless candles are tried, examined, and the imperfectly burning ones rejected, grave discrepancies may arise. Even when all these things have been done, the results obtained from one pair are not to

be relied upon as indicative of what we must be content with —namely, average value.

In the long series of experiments which I have lately made, the extreme difference in the indicated power of an absolute 5 cubic feet per hour flame of 15-candle gas tested against 7 pairs of candles consecutively was 1·1 candles, but the extreme difference between 6 of these pairs was less than half a candle. On occasions when 3, 4, 5, and 6 pairs were consecutively used, the difference ranged from 1-10th to 6-10ths. In Table II. [see p. 1058] the error is greater, being 1·348 candles. These differences as given were existent after correction for rate. An important objection is that candles which burn near to the standard rate cannot always be obtained. I have had a batch of several hundredweight, in which the candles were almost perfection, while these have been succeeded by others quite useless for photometric purposes under any such limitation as a 10-grain divergence from the standard rate. I cannot resist remarking that it has been a subject of some amusement to me to find photometrists sending hither and thither for sperm candles to supposed makers, in order to find the best producer; in ignorance the while that the candles they obtain, if of pure sperm, were made by the same person as those which caused dissatisfaction. I only know of one maker of true sperm candles in London, and he takes almost a scientific interest in the production of such as are fit for photometry; for, commercially, the matter is far too small to be of any interest to him. That gentleman is Mr. Miller, of Westminster, and it is but justice to him to say that I am indebted to him for his willing aid in making samples when I have sought to produce satisfactory candles. Doubtless there are others who are under similar obligations. I would long since have had moulds made and candles 12 to the pound produced, but for the absurd stipulation in Acts of Parliament that the candles are to be 6 to the pound. Twelves could have their wicks more truly centred, would taper less, and might be more equal in density, for "head" in the mould would be obtained by very simple means.

Among the standards which have been proposed are—a mixture of hydrogen and olefiant gases in certain proportions; the Carcel lamp of France (with which colza oil is burned); the sperm oil lamp of Mr. Keates; Mr. Vernon Harcourt's pentane gas; and the standard of Mr. Methven.

The original idea of a gas standard is revived by Mr. Harcourt, but in a new and better way. It is, so far as my experience with it goes, superior to the sperm candle; but notwithstanding my admiration for Mr. Harcourt, both as a gentleman and as a scientific man, and the respectful esteem which I entertain towards him, I am compelled by honest conviction to say reluctantly that I am not in love with his proposed standard. A new standard should entail little, if any, extra cost; should be portable, require little preparation, and demand the least possible time and trouble. To use again the expression I employed in 1870, I say: "Whatever be the future system of testing the illuminating power of coal gas, it must, in order to serve the interests of the consumers generally, be quite as facile in application as the present system, and be of a simple character, so as to render the test available, not only in the large towns and cities, but even in the smallest village in the United Kingdom in which gas is used."

It appears to me that Mr. Harcourt's standard fails to satisfy such conditions. In addition to the usual photometric apparatus, a 5 or 6 cubic feet gasholder is needed, besides an extra and delicate meter of very small capacity, an extra governor, and a special burner; these must be fitted up with a perfection, as regards soundness of pipes and joints, such as is rarely attained. Cost is therefore greatly increased, while portability is not, in a reasonable sense, possible. Three or four hours before a test can be made the pentane gas must be prepared—an operation occupying from 10 to 15 minutes, and involving an observation of barometric pressure and of temperature, and a calculation of the bulk of air to which a measured volume of pentane is to be added. When so prepared, the quantity of gas which results will, however, suffice for about a week's daily testing.

In respect to lamp standards, I am bound to say that the very large number of trials which I made with the Carcel lamp in the year 1867 indisposes me to put faith in any lamp with which fatty oils are burned. I say fatty oils, because some recent trials with lamps burning paraffin oil were indicative of great steadiness and of uniformity of lighting power. I have not had time, however, to make extended tests. The objections which I have to such lamp standards as have been used are that they require too much time and attention devoted to them; they must be kept in a state of perfect cleanliness; the wick must be renewed very frequently, if not on every occasion of using (this last I deem essential with the Carcel); the wick must be trimmed with extreme care, and it and the chimney adjusted to the utmost nicety of exactness; and when all has been done there is no certainty that the rate at which the oil burns will not be greatly in excess of a standard rate. The variation in rate would be of no consequence were it not that, as my experiments show, the amount of light yielded increases sometimes in a much greater ratio than the consumption of oil. It is difficult to keep the consumption of the Carcel lamp so low as the standard rate of 648 grains per hour. Only on one occasion did I get the rate below—*i.e.*, to 644 grains. Calculated to 648, the lighting power of the lamp was equal to 8·21 sperm candles. Increased rates of consumption gave different values when duly calculated for 648 grains—thus 10 per cent. increase in consumption gave 8·999 candles, or 9·5 per cent. increase in light; while 12 per cent. increased consumption gave 20·1 per cent. more light, or 9·86 candles power. In some few cases there was a marked reduction in light. In one case with 6 per cent. excess in consumption the value of the lamp was under 8 sperm candles. On every occasion the greatest possible care was exercised in trimming, adjusting, and using the lamps; for, although I have used the word lamp in the singular, I operated with two.

Sperm oil is unquestionably better than colza, as the former can be obtained of almost uniform quality, and does not thicken and become viscid, while the lamp devised by Mr. Keates possesses characteristics which tend to render combustion perfect, maintain the oil supply regular, and, as a consequence, the light emitted uniform in power; but whether this lamp would bear the test of severe crucial trial I cannot say, as it has never been in my possession.

Having stated what I deem to be the needful characteristics of a photometrical standard, and called your attention to the imperfections of the existing one, and also to the defects or inconveniences associated with others, I now come to that proposed by Mr. John Methven in the paper which he read before the Association two years since. Some of the members will possibly remember that at that meeting, and afterwards in letters to the JOURNAL OF GAS LIGHTING, I disputed the possible correctness of Mr. Methven's assertion that "portions of the flames of gases of varying qualities, ranging in illuminating power between 15 and 35 candles, consumed so as to effect perfect combustion by similar burners, are equal in illuminating power." My reasonings were correct in principle, and so, of course, remain, but their weakness consisted in the fact that they were based upon an exaggerated idea of the differences in power of the light emitted by the various parts of an Argand flame; and although I carefully read Mr. Methven's paper, it failed to alter my impression. When I tried the instrument with rich and poor gas, I was convinced, and admitted my errors in a published letter.

After operating many months with this proposed standard, I am now able to speak about it with the confidence due to experience, and as at first I was its most active opponent, and, further, as it is always my desire, in matters relating to science and practice, to *be* right rather than by specious argument to attempt to show that I *am* right, I concluded that, in justice to Mr. Methven, I was bound on this occasion to come before you as an advocate for that which I at first condemned. I put myself, as it were, into a sort of moral pillory, and am content that you should, as I hope you will, assail me with all the missiles of argument which you can find, feeling as I do quite sure that in this Association I shall be safe from the rotten eggs of offensive expressions.

Mr. Methven's proposed standard consists of an upright screen with a "London" Argand burner fixed at a certain distance behind it, the screen having an opening or slot at a determined height above the level of the top of the burner. When in use the screen is made to coincide with the terminal point of the photometer-bar, taking up the position which the candles generally occupy. When properly applied the only rays which can impinge on the disc are those which pass from the flame of the burner through the slot in the screen. The slot may be varied in size so as to permit the passage of quantities of light varying from 1 to about 2·5 candles power; but I prefer at present that it should be of such dimensions as will allow of the passage of as many rays as are equal to the light of two average sperm candles—viz., nearly 1 inch long and ¼-inch wide. This seems to be the size which best suits the burner. Provision is made for the ready use of candles as well as of the screen.

Having made and worked with a number of screens of different sizes, and with gases of different qualities, I fixed upon the screen indicated as F as most suitable. The slot in this is 9-32nds inch wide, and ¾-inch long. This screen was

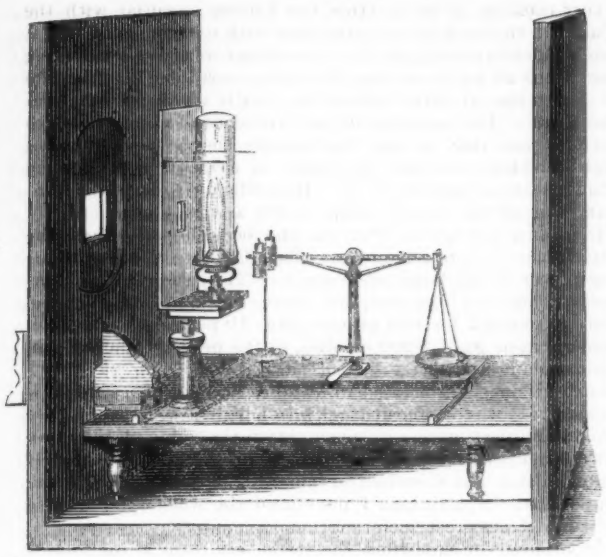

ILLUSTRATION SHOWING THE APPLICATION OF METHVEN'S STANDARD SCREEN TO A LETHEBY PHOTOMETER; the Candle Balance being on Rails ready for the prompt Use of Candles in lieu of the Screen.

not fully satisfactory under the severe test of 35-candle gas. I therefore made four others, the dimensions of the slots of which were calculated from the results obtained with the screen F. Of these No. 3 proved to approach nearest to 2-candle power, and was adopted for the crucial tests; the others, however, were very near to it in power, as a number of trials showed.

Table I. shows the amount of light which appeared to pass through the slit of F in candle power with gases varying by candle estimation from 12·4 to 15·05 candles. The extreme variation of the power of the gas is 21·3 per cent., while the extreme difference between the value of the screen's power is 5·4 per cent. only. My conviction, however, is that the light through the screens was practically constant, although the height of the slot above the burner was greater than that afterwards decided upon as correct. The indicated variations were, without doubt, due entirely to the candles. My reason for stating this is that I used the F screen in making a considerable number of experiments with paraffin lamps and with gas-burners, and I found such harmony and consistency in the results as satisfied me that the standard light was uniform in power, or, if at all affected, only by temperature and pressure in the same ratio as the contrasted flames.

Table II. exhibits the results of tests with No. 3 screen at the height above the burner finally selected. It will be seen that with a 5 cubic feet per hour flame of common coal gas of 14·02 candles power, the difference in the photometric readings between a 3-inch Argand flame from the same gas, and from gas of 35·37 candles power, was only 0·7 per cent. The second series is set out more fully, and shows that the candles indicated the power of the common gas to be as low as 13·24, and as high as 14·588, a difference of 1·348 candles, or 10·11 per cent., while the screen used with common and cannel gas gives an extreme difference of only 0·83 per cent., and a mean difference of 0·3 per cent. only.

Table III. is derived from results set out in Table II., and is somewhat striking, as it shows how much the power of screens may appear to vary as the lowest or highest power of the gas, as indicated by candles, is taken as a dividend to be divided by the mean of the indications obtained with a screen standard, ranging as they do with common gas from 1·8388 to 2·0197, and with cannel gas from 1·8325 to 2·0124, the difference in the mean value between common and cannel gas being, of course, the same, or nearly so, as in Table II.; any difference being due to limitation of decimal figures.

It is well for me to say that all the screens yet produced have been hand-made, and the size of the slots finally settled by photometric observation. It is my intention to form the slots with a perfect die of the correct dimensions. Lest, however, it should be thought that there is any grave difficulty in their production, I caused two other screens to be made, and they were compared with a 5-feet Argand flame, the value of which had been ascertained by three pairs of candles, as shown in Table IV. The difference in indicated illuminating power with candles is 0·92 of a candle, which is equal to 5·9 per cent. The screen renderings range from 8·1 to 8·18, or a difference of only 0·61 per cent. The last is a very small percentage, when consideration is given to the fact that the screens Nos. 5 and 6 were, with intention, somewhat hastily made. Here again we find the apparent powers of the screens changing as we calculate the illuminating value of the opposed gas-flame by the several candles employed; the mean in this instance for No. 3 being 1·958 with common gas, as against 1·96 in the previous example—a difference of 0·2 per cent. Other screens have since been made slightly larger, and as, I believe, of 2 candles power.

It is important to observe that in all the earlier trials, chimneys 1¾-in. × 6-in. were employed with the standard; but as with these a satisfactory 3-inch flame could not be obtained when the rich cannel gas was used, a 2-in. × 6-in. chimney was afterwards adopted, and with advantage.

The evidence which has been adduced is, I think, enough to convince you that Mr. Methven's statement is true; but it may be asked—If it be the case that portions of the flames of gases of varying qualities, burned properly from similar burners, are equal in illuminating power, is it not also true, as asserted by Mr. Sugg, and I believe for the first time publicly, that the quantity of light yielded by Argand flames of the same length, but from different qualities of gas, is also equal, if the conditions be the same and the burners and chimneys are identical in size and character? To this I frankly reply—Yes, or very nearly so, in my experience; but the difficulty I find is in accurately defining the length of the flame, for, with all the burners I have tried, each flame terminates, not in a horizontal ring, but in an irregularly defined figure, approximating to an oval, inclined at an angle, and ever changing in shape; while the flame tends to rotation round its vertical axis to the extent of nearly a quarter of a revolution. These effects are due to slight disturbance in the surrounding air, and to vibrations. It has only been by patient waiting that I have at times obtained flames truly 3 inches in length, and only when all around has been abnormally quiet. Then the results have been very close. In other instances, although trouble was not spared, the discrepancies have ranged up to as high as 8 per cent.

No such nicety of adjustment is needed with Mr. Methven's standard, 1-10th or even 1-8th of an inch in excess or in deficit in the length of the flame is of little or no consequence. Neither is it of vital importance that the top of the flame shall be absolutely regular. Not that I suggest that any proper condition or needful adjustment should be disregarded. The burner should be of the best, the chimney and the screen clean, the adjustment of height of flame made carefully, and then examined from time to time. All these attentions cost little trouble, while the determination of the real power of the opposed flame may be made in a minute or two. One thing is important, as it always is in photometry—viz., to burn off the "dead gas" in the fittings before testing. If the perfectly ridiculous and patience-trying obligation did not exist, of adjusting the gas to be tested to the 5 cubic feet rate, the flame length of Mr. Methven's standard could be adjusted, the disc placed in the position required on the photometer-bar—that is, at 7, 8, and so on, for 14, 16, and higher qualities of gas—the micrometer turned on until the opposing lights were equal, a few observations made, the rate of consumption taken as indicated by the meter, and the whole operation completed within five or six minutes.

I have been hoping year by year from 1857 to see such changes made, that the value of gas should be ascertained by the quantity required to produce a certain lighting effect, and not, as now, the light given by 5 cubic feet. Whether the proposed standard will ever become a legalized one remains to be seen. I have done a duty in again bringing it under your notice, and it will be well for you to consider whether it is not worthy of your adoption and trial in daily use, for the time being, as a secondary standard.

In the first portion of this paper I have dealt with certain facts and particulars with which you are familiar, and have done so for two reasons—first, to make the paper as complete as half an hour's time in the reading would permit; and, secondly, that it might serve as a sort of *aide-mémoire* for the purposes of discussion.

[For Tables, see next page.]

Discussion.

Mr. W. SUGG said he had listened with great pleasure to this paper, and it was very pleasing to hear Mr. Hartley retract what he had said with regard to Mr. Methven's test; but it was only to be expected that he would do so. He (Mr. Sugg) wanted, however, to say a word in favour of the sperm lamp proposed by Mr. Keates and himself as a standard light. All parliamentary standards must refer to something independent of gas; and feeling this strongly, and feeling also that candles were so unreliable—for he had compared

TABLE I.

Screen F too High above Burner.

Illuminating Power of Gas by Candles.	Apparent Value of Screen.
13·18	1·922
13·16	1·853
12·40	1·856
15·05	1·892
14·25	1·822
14·63	1·872
14·73	1·896
14·49	1·851
14·78	1·852
14·73	1·901
Candles (direct comparison)	1·917

Extreme difference shown for value of screen by candles, 5·4 per cent.

Extreme difference in value of gases used as indicated by candles, 21·3 per cent.

TABLE II.

Screen No. 3 in proper Position.

First Series.

Illuminating power of common gas	14·02
„ „ cannel „	35·37
Screen with common gas	7·10
„ cannel „	7·09

Difference, 0·7 per cent.

Second Series.

Illuminating power of common gas.

By 1st pair of candles	13·24
„ 2nd „ „	14·588
„ 3rd „ „	14·58
„ 4th „ „	14·062

Average, 14·117.

Illuminating power of cannel gas	35·37	candles.
Screen with common gas	7·20	„
„ „ „	7·20	„
„ cannel „	7·26	„
„ „ „	7·19	„
Mean common gas	7·20	„
„ cannel „	7·225	„

Extreme difference by candles, 1·348 candles, or 10·11 p. ct.
Extreme difference by screen . 0·83 per cent.
Mean „ „ . 0·30 „

TABLE III.

Values of Screen No. 3 calculated on Illuminating Power as indicated by Four Pairs of Candles. (Table II.)

Candles.	Cannel.	Common.
1st pair	1·8325	1·8388
2nd „ } 3rd „ }	2·0124	2·0197
4th „	1·946	1·954
Average	1·950	1·958

TABLE IV.

Comparisons of Screens with Common Gas.

Illuminating power of gas.

1st pair of candles	15·48
2nd „ „	15·64
3rd „ „	16·40

Average, 15·84.

Extreme difference by candles, 5·9 per cent.

Readings with Screens.

No. 3.	No. 5.	No. 6.
8·1	8·13	8·18

Extreme difference, 0·61 per cent.

Values of Screens calculated on Illuminating Power indicated by Candles.

Candles.	No. 3.	No. 5.	No. 6.
1st pair	1·911	1·904	1·880
2nd „	1·939	1·923	1·900
3rd „	2·024	2·017	2·005
Average	1·958	1·948	1·928

them on a former occasion to an india-rubber rule—Mr. Keates and himself proposed adopting a standard light from pure sperm itself, unmixed with any other matter. With the makers of sperm candles, the great difficulty was to get a pure sperm; and, secondly, to make a mixture of it with wax or some other substance, so as to obtain a candle which would be homogeneous. The same with regard to the cottons, and the way in which they were twisted. This also produced uncertainty. But by taking sperm oil itself, and by using it in a lamp with a burner like the Argand, so as to produce a light equal to the gas about to be tried, there was no multiplication of errors in the observation. He had shown that if two candles were taken to test 16-candle gas, the slightest error was multiplied by 8; but if a flame of 16-candle gas was used, and this was compared with a 2-inch flame of a spermaceti lamp, that would give exactly 16 candles. The sperm lamp, however, did not succeed well when tried by the Commissioners appointed to test the standards, because they said it took too long to get into burning order—something like 20 minutes; but the moment it was in burning order it would go on for two or three hours without any sensible variation. The thing then required was that it should take less than 20 minutes to get it in order. The Metropolitan Gas Referees prescribed that the gas should burn for a quarter of an hour or so before the tester commenced making his examination. Therefore, if they lit up the lamp at once, and let it get into proper burning order—the candles would take 10 minutes, so that there was only 10 minutes difference—it would be in burning order by the time they were ready to take the observation, and the light was then constant and reliable. With regard to Mr. Methven's test, the standard burner of the Gas Referees must be used, because if another burner was taken, such as that used by consumers, where the air arrangement was a little different, the same accurate result was not obtained as by using the Gas Referees burner. Otherwise, Mr. Methven's apparatus was, for ordinary purposes, where there was only a variation of, perhaps, one, two, or three candles, a very good standard.

Mr. R. O. PATERSON (Cheltenham) said he could not quite agree with the opinion Mr. Hartley had expressed as to the inapplicability of the test proposed by Mr. Vernon Harcourt. If a reliable and correct instrument or means of measuring light could be applied, he hardly thought the little trouble necessary to make the appliance perfect could be urged as an objection to it. Mr. Harcourt had shown on more than one occasion that it was extremely easy and simple to make the pentane gas. If it took ten minutes or quarter of an hour once a week to prepare the gas which then gave a reliable and accurate test, the time thus occupied could hardly be urged against the system. He believed that it was quite reliable, and Mr. Harcourt had such confidence in it that he would allow the utmost liberty to be taken with his apparatus. It was not necessary to have a gasholder in the laboratory; and there was apparently no difficulty in the preparation of the gas, other than the few minutes necessary to fill the gasholder with air, and add to it the measured quantity of the pentane, which was immediately volatilized. Whether this standard was likely to come into use was another question. He must say that, looking at the instrument of Mr. Methven, he (Mr. Paterson) was more inclined to doubt its applicability to the estimation of the illuminating power of gas than he was the adoption of the pentane test. What Mr. Sugg said about the burners showed that at the height at which the slit was fixed there might be variable amounts of light, and consequently the standard was variable. He should like to know what candles were to be taken as fixing the standard, for he could give candles which would show a difference of 2½ candles with the same sample of gas. The tendency appeared to be to depreciate the candle and fix some other standard; but they must all be fixed originally by the candle, and therefore the question arose which candle should be accepted as the standard by which to measure the new standard.

Mr. C. E. JONES (Chesterfield) said if they were to give up the old candles, they should be very careful what standard for comparison they adopted. It had been shown that there were sources of error to a considerable magnitude by the standards proposed in lieu of the candle, and he rose rather to express some doubt as to the extreme variations in the much-abused candles, and to exhibit an amount of confidence in them far above that shown by Mr. Hartley or Mr. Sugg.

Mr. T. NEWBIGGING (Manchester) thought it was generally admitted that the defects of the test candle were principally associated with the wick, and that the sperm itself, if used as a lighting medium without a wick, would probably give a nearer approach to perfection in testing gas than anything

else. It appeared to him that it was scarcely fair to test their weights and measures by their own weights and measures. For instance, they had inspectors going about the country and seeing that the weights used in trade were of the proper standard; but it would scarcely do for a person to keep two sets of weights on his premises in order that the one might be tested by the other. This seemed to him a parallel case to testing gas by means of their own and the same identical gas, and there was no doubt, as Mr. Sugg had shown, that, owing to the variable qualities of flames of the same gas, it was difficult, if not impossible, to obtain a proportion of any flame which would give a satisfactory test of the quality of another. The same objection did not apply to the use of sperm, pure and simple; and if Mr. Methven or Mr. Hartley, or any other experimentalist, were to contrive a wickless lamp, by means of which they could test gas with a proportion of sperm light projected through a slit, instead of gaslight, they would have a standard that would be much less objectionable, and one that might be expected to answer every purpose.

Mr. J. Somerville, following up Mr. Newbigging's idea of weights, said for some time past they had had in use, at the South Metropolitan Gas-Works, these three sets of weights, which he might call weights of brass, of lead, and of copper, representing the sperm candles, the pentane, and Methven's slot; and they found, in testing the gas, that all these standards or weights agreed very nicely. The pentane was as near as possible equal to the candles, and Mr. Methven's slot 1 inch long and 9-32nds inch wide, taken out of the centre of the flame of the same gas, was exactly equivalent to the sperm candles burning 120 grains an hour, and to Mr. Harcourt's pentane. The great difficulty was in getting the candles into order for testing, and making them reliable. There was a great deal more trouble, especially in extremes of temperature in summer and winter, in preparing the pentane, because the temperature had an influence on the vapour of pentane, so that it had to be corrected for temperature, &c. With Mr. Methven's slot it was perfectly easy. One could see at a glance the exact illuminating power of any gas, and without any preparation—it was always ready. To his mind there was not any difference in the three weights or standards, and he only wished the Legislature would sanction the Methven slot as a standard by which to test gas.

Mr. R. Morton (London) thought Mr. Newbigging's argument about the weights was really more sentimental than anything else. Whether this became a legal standard or not, to gas managers who were obliged to test their gas two or three times a day, and had not much time to do it, a standard which was brought into use in a moment was of much greater value than one which required even five minutes to put into operation, and this was much more reliable than candles. It was no breach of confidence for him to say that those gentlemen who were inquiring for the Board of Trade into the standards used in estimating the illuminating power of coal gas, were going into this matter pretty fully, and he believed, so far, they were very pleased with Mr. Methven's apparatus.

Mr. Hartley said it was almost refreshing now-a-days to hear a good word said for the sperm candle, as Mr. Jones had in his remarks. He (Mr. Hartley) had used them for many years, and they seemed to act better in his hands than in some people's, and if he had, in the experiments referred to in his paper, pursued his usual course, he should not have shown such great differences as were indicated in the tables exhibited. If he found that candles varied unduly, he did not accept the indicated results. He exercised his own discretion, just as the testers did in Paris, where they used the Carcel lamp, although they were supposed to be strictly following the rules laid down by Dumas. In his paper, however, he had felt it to be his duty to give the results he had obtained, in order to show how far candles might differ as compared with Mr. Methven's standard. Mr. Newbigging's argument had been already dealt with, and he did not see the slightest reason why they should not weigh a thing by a certain quantity of itself. In using this weight (so calling the screen) any one could satisfy himself that he had the right quality and quantity on both sides. It might be suggested that gas managers could make their gas of low quality, and so use the screen as to deceive the public or the testing inspector; but no such thing could be done if the inspector had the slightest judgment in him, for the simple reason that as the gas went down in power the blue of the flame would reach the screen. He could see to the sixtieth of an inch whether the screen was in its right positio nor not in relation to the blue part of the flame. Mr. Somerville had confirmed some of the statements he (Mr. Hartley) had made. He had learned that a favourable result had ensued from trials with the screen at the South Metropolitan Gas-Works, and the lecturer the previous evening also spoke in favour of the screen standard. With regard to Mr. Paterson's observations, he must remark that he spoke very reluctantly against the pentane standard, because he had been so much associated with Mr. Vernon Harcourt, and so much esteemed and admired that gentleman, that he scarcely liked to say a word in antagonism to any project of his. He (Mr. Hartley) had been a worker with the pentane standard, and had made the instruments Mr. Harcourt had put up and worked with; but he (Mr. Hartley) had unwillingly come to the conclusion that Mr. Harcourt's standard was scarcely the right thing. Photometric apparatus of the simplest kind was costly. Small gas companies obtaining Provisional Orders from the Board of Trade were compelled to procure a photometric apparatus, and the pentane standard meant an addition of something like £40 to the ordinary cost. Again, it could only be used by those who perfectly understood all that belonged to gaseous volumes, and unless the pentane gas were carefully made, there might be errors, and its preparation involved calculations. Now, there were many of their friends who hardly had time or inclination for such a thing as this; and, further, they must have all joints and pipe-fittings sound to an unusual degree. To put another case, supposing a gas company were going in for an Act of Parliament, and an expert were suddenly called upon to investigate the quality of the gas for the purpose of giving evidence before a Parliamentary Committee. He could not put a 5-feet gasholder in his pocket, and take it down with him and set it up. He might also only have a limited time in which to make his investigation. Mr. Harcourt's standard involved the necessity of one, two, or more days of preparation in order to get things in readiness. It appeared to him, therefore, that that gentleman's test did not possess the universality and promptness of application which was required in a new standard. He thanked Mr. Sugg for the kindly way in which he had dealt with the subject. He had spoken of the sperm lamp of Mr. Keates, which he had used, and he (Mr. Hartley) was prepared to admit that Mr. Keates's lamp was an excellent one. He was only sorry he had not the opportunity of using it. Still the general objections to lamps remained unanswered—viz., that they required a great deal of trouble, whilst the screen standard required none. The lamp needed preparation beforehand, and to burn about twenty minutes before it was fit for using. This he had no objection to, and so far he was prepared to believe with Mr. Keates and Mr. Sugg that the lamp was decidedly better than candles. But if they could have something simpler, which could be more readily applied than a lamp, why should they not have it, although they were measuring the value of a thing by a portion of itself? Mr. Sugg had also made some observations as to the proportion of error which might arise with candles. He said that if candles were used any errors were multiplied. This was perfectly true, and if he had established as a fact that the lamp was practically constant, such errors were disposed of; but he could not grant absolutely that in the use of lamps there might not be errors as great in their import as belonged to candles themselves. However, he was content to accept Mr. Sugg's statement. Mr. Sugg also said that Mr. Methven's standard required a standard burner. He might compliment Mr. Sugg on the adoption of the standard burner. It was so adopted in order to secure the advantage of it and the opposed burner being of the same character. But when Mr. Sugg said the ordinary burner could not be used with the screen, he was only correct to a certain extent. Whatever position was established for a particular burner remained effective for that burner; and hence he might take one of Mr. Sugg's consumers burners, and by mere alteration of the position of the screen render that burner as effective for the purpose as the "London" Argand.

(X.)

THE CHEMISTRY OF SPENT LIME.

By Mr. W. Foster, M.A., F.C.S., &c.,
Professor of Chemistry at the Middlesex Hospital.

Some years ago Dr. Voelcker made an analysis of gas lime, the result of which was published in the Journal of Gas Lighting. The figures of the analysis are given by Mr. Newbigging in his "Gas Manager's Handbook." I am not aware of any other published analysis of gas lime or spent lime, and as the specimen on which Dr. Voelcker worked was one which had been freely exposed to air for a sufficient length of time to admit of its being safely used as a manure, its chemical characters were not those of the fresh gas lime.

Lime which has been converted by carbonic anhydride into calcium carbonate is perfectly inert as a purifying

material. A few weeks ago, when the subject of this short paper was brought under my notice, I was informed that Mr. Robert Harris, of the Bow Common works, was employing a simple process for "revivifying" the spent lime obtained in sulphur purification. This led me to communicate with Mr. Harris, who at once gave me full information respecting the plan he employs. He also furnished me with various specimens of lime for analysis.

The essential character of this paper is an account of the spent lime obtained by Mr. Harris's method of working. At first I was under the impression that the lime was used as recommended by the Gas Referees—that is, for the complete removal of carbonic acid before the crude coal gas is treated for "sulphur compounds" by means of special foul lime. In this I have been mistaken. The spent lime on which I have made my experiments is that produced by Mr. Harris in his treatment of sulphur compounds generally. Before considering the nature of the spent lime itself, it is important that I should give an account of the crude gas before it reaches the lime purifiers. Before passing through the lime, the crude coal gas has been washed and scrubbed with water and ammoniacal liquor. The latter used in this instance is in the condition in which it leaves the hydraulic main and condensers.

Mr. Harris has made determinations of the carbonic acid and sulphuretted hydrogen present in the gas after it has been washed and scrubbed with the liquids named. The numbers obtained were as follows:—

Carbonic acid	2·3 per cent.
Sulphuretted hydrogen . .	1·3 „

I believe these numbers approximately represent the average character of the crude coal gas with reference to these gaseous impurities. The impure coal gas then passes direct into the dry caustic lime, where it loses carbonic acid, sulphuretted hydrogen, and "sulphur compounds" other than sulphuretted hydrogen. The lime purifier is kept working until the quantity of sulphur compounds at the outlet of the purifier is nearly as great as at the inlet. The lime is now in a condition in which it is no longer serving a useful purpose in gas purification, and the purifier containing it is shut off from the gas stream. But although no longer useful in its present condition, there is still a large proportion of unaltered caustic lime present. A certain quantity of work has been done by the lime in removing impurities from the gas, whereby a given quantity of calcium compounds has been formed; but there still remains enough unaltered lime capable, under changed conditions, of discharging a second quantity of work equal in amount to that first performed. This is Mr. Harris's experience.

To get this second quantity of work out of his lime, Mr. Harris proceeds as follows:—The lime purifier shut off from the gas supply has atmospheric air driven through it, which in turn is made to traverse an oxide of iron purifier, so that any nuisance which might arise from sulphur impurities is avoided. The lime is then removed from the purifying vessel and spread on the dry floor of a shed. It is turned over twice by workmen with shovels, and then returned to the purifying vessel. The time occupied in exposing the lime is usually about a week. This exposure of the partially saturated lime to air destroys the hard and crystalline character of the fragments, which, no doubt, contain in their interior the portion of lime still in the condition of hydrate. Whether such a process can be called one of "revivification" is of little practical moment. The process, however, does not involve any chemical action, so far as I at present know, and in that particular entirely differs from the process of exposing oxide of iron to air. A portion of lime converted into carbonate remains as such, and acts as a diluting and inert component of the whole. The partially exhausted lime, after a second exposure to the purifiers, is found to be practically exhausted, and is removed as waste.

I have examined some of the fully spent lime produced in the above manner of working, as devised and practised by Mr. Harris—that is, dry caustic lime saturated up to a first limit with impurities, then exposed to air in the way I have described, and again saturated up to its final limit with impurities. A sample is on the table. It is in a dry pulverulent condition, having a greyish colour. Its chief constituents are—

Calcium carbonate.	Free sulphur.
„ hyposulphite.	Naphthaline.
„ sulphocyanate.	

Calcium carbonate is, of course, the most abundant component. Calcium hydrate is absent, so that the sample has done all that is possible under ordinary conditions. Sulphur is present in at least three forms, the total amount of the element being by no means inconsiderable. As the result of several determinations which I will presently refer to, I find 8 per cent. When the spent lime is treated with water or spirit and filtered, a slightly coloured liquid is obtained. In each case when a few drops of ferric chloride solution are added, a deep red coloration characteristic of a sulphocyanate is produced. The aqueous solution bleaches free iodine or bromine. If warmed with a few drops of hydrochloric acid and allowed to stand a few minutes, the solution becomes turbid, owing to separated sulphur, whilst at the same time the odour of sulphurous acid is distinctly recognized. These indications point to the presence of hyposulphite. The original spent lime, treated with bisulphide of carbon, forms a clear brownish-yellow liquid. When this is decanted from the insoluble residue, and evaporated to dryness by the aid of a gentle heat, a quantity of free sulphur is obtained mixed with naphthaline. Special precautions have to be adopted in order to determine the total sulphur present, otherwise some of the element may escape as a gaseous compound, whilst a second portion, in the form of free sulphur, may escape oxidation. The simplest plan is to treat a weighed quantity of the spent lime, placed in a small flask, with an excess of fuming nitric acid (sp. gr. 1·5). It is well to place the flask in a large glass jar provided with a ground glass cover. The acid can then be poured quickly down a tube funnel on the lime, the funnel withdrawn, and the glass cover placed on the jar. The flask can be removed from the jar at the end of an hour or two, warmed, and in that way complete oxidation of the total sulphur to sulphuric acid is effected. The sulphur is then determined as barium sulphate in the usual manner.

A weighed quantity of the completely spent lime was treated with carbon bisulphide, and thoroughly exhausted by means of that liquid. The carbon bisulphide solution was then evaporated to dryness, and the free sulphur in the residue determined as above. The residual mass deprived of its free sulphur was then separately oxidized, and the combined sulphur determined. The combined sulphur is that existing in the spent lime as hyposulphite and sulphocyanate. The mean of several experiments gives—

Free sulphur	4·06 per cent.
Combined sulphur . . .	4·02 „
Total sulphur . . .	8·08 per cent.

Some experiments have been made on lime which is only partially converted into carbonate and sulphur-calcium compounds—that is, half-spent lime. The condition of my specimen is that in which it is returned to the purifier for second treatment. It contains sulphocyanate and hyposulphite, but the presence of free sulphur has not been experimentally proved. The total sulphur has been determined, and is 6·1 per cent. There is also a large quantity of calcium hydrate; and the chief object of my investigation of this part of the subject has been to devise a ready and efficient method of determining the amount of unaltered hydrate in specimens of partially spent lime, so that the engineer may have some means of calculating its purifying capacity when it is again returned to the purifier.

The sparingly soluble character of calcium hydrate prevents its separation, by means of water, from the other constituents of the spent lime. The process I have devised for my present inquiry consists in adding an excess of a solution of a copper salt to a weighed quantity of the lime. The calcium hydrate furnishes a precipitate of hydrate of copper, the excess of the copper salt remaining unaltered in the solution. Knowing how much copper salt was first added, and then determining how much remains behind in solution, the difference between the two represents the amount of copper thrown out of the solution as hydrate. The equivalent of this quantity of copper hydrate in terms of calcium hydrate is the amount of calcium hydrate in the quantity operated on. I have proceeded as follows:—A weighed quantity of spent lime (between 30 and 40 grains) was placed in a 100 cubic centimètre measuring flask, and standard cupric chloride solution added up to the measuring line. The whole was allowed to stand for a few hours with occasional agitation. A measured quantity (10 c.c,) of clear liquid was then withdrawn by means of a pipette, placed in a suitable cylindrical vessel, and excess of ammonia added. The blue liquid thus formed was then diluted to a convenient extent with distilled water. Ammonia and distilled water were next placed in a second similar cylindrical vessel, and some of the standard cupric chloride solution run in until the same depth of blue colour, as seen by looking down through the column on a white surface, was obtained. Ascertaining how much of this standard cupric chloride solution is equal to that present in the 10 c.c.

of liquid, it is at once obvious how much is equal to that in the whole 100 c.c. The amount of cupric chloride present in the original 100 c.c. being noted, and that now present being ascertained, the difference between the two quantities is the amount of cupric chloride removed as hydrate from the solution. Its equivalent of calcium hydrate can readily be calculated. Proceeding in this way, my sample furnishes 21 per cent. of unaltered calcium hydrate. Now, as calcium sulphocyanate, in particular, causes a precipitation of some copper, I bring the process forward merely as a rough method, and as the best which has yet occurred to me. With a little care it may render good service.

I now come to a consideration of the condition of the sulphur in the spent lime. The cause of the presence of the free sulphur is to me least intelligible. I have already stated that sulphur is present in *at least* three conditions, and it is most probable that a portion is present in a fourth condition —namely, as sulphite; but on this point I have no positive information. One may reasonably suppose that there are three calcium compounds containing sulphur produced in the lime purifier when crude coal gas, such as I have described, is passed into it. These are calcium sulphide (Ca S), calcium sulphocarbonate (Ca CS_3), and calcium sulphocyanate (Ca 2CNS). When calcium sulphide is exposed to atmospheric oxidation for a limited time in the presence of caustic lime, calcium sulphite and hyposulphite are produced. When calcium sulphocarbonate is similarly exposed, calcium carbonate and sulphuretted hydrogen are produced, especially if moisture is present. As caustic lime is an important constituent of partially spent lime, one would expect that this sulphuretted hydrogen would produce an additional quantity of calcium sulphide. It is also known that alkaline sulphocyanates undergo slow decomposition in the presence of moisture, yielding ammonia and a carbonate of the base; and one would expect a similar result with calcium sulphocyanate. But there is no evidence to show that the sulphur of an alkaline sulphocyanate separates in the free state. Therefore, so far as we know respecting the independent behaviour of each of these three calcium sulphur salts, we have no clue to the origin of the free sulphur in spent lime. It may be due to their mutual action, but this is by no means obvious. I am much more inclined to believe that I have only partially stated the facts, and that we have more to learn respecting the nature of the calcium-sulphur compounds produced in the lime purifier.

I may mention that I have examined a specimen of spent lime produced at the works of the South Metropolitan Gas Company. The crude coal gas in this instance had been treated with Hills's liquor, and was therefore in a different condition from that produced in Mr. Harris's method of working; that is, so far as sulphur and other impurities are concerned. The specimen on the table has a different physical character from that obtained at Bow Common. The only experiments I have made on it have been to determine its total sulphur. This I find to be 8·4 per cent. Such a result would scarcely be expected from an inspection of the specimen, especially after what is known respecting the amount of sulphur present in the grey pulverulent waste lime made at Bow Common.

In conclusion, I regret that I am unable to throw more light on this most intricate and least understood branch of the gas manager's art.

Discussion.

Mr. R. Harris (Bow Common) said that, as his name had been frequently mentioned in the paper, it might be desirable for him to give some information as to his mode of working. About 13 years ago he adopted the principle of removing the sulphur compounds other than sulphuretted hydrogen, commonly known as bisulphide of carbon, from gas by means of sulphide of calcium produced from pure caustic lime by the action of crude gas upon it. In changing the purifiers as used for this purpose, he found there was a considerable amount of nuisance, and to obviate this he adopted a system of drawing air through the material before the purifiers were discharged. This went on for some time, his lime account representing only 17 tons of coal per yard of lime. At length he noticed that the lime, after it had been ventilated by air and removed from the purifier, had much the same appearance as when put into position. He accordingly took steps to ascertain how far it had been used up, and from some rough experiments he found that about 40 per cent. had not been utilized. Feeling that this was a considerable waste, he endeavoured to see how far it could be prevented, and the first thing that occurred to him was that, instead of taking the lime out of the purifiers when it had been ventilated, the best thing would be to turn the gas through it again; but this was not very effectual. He then adopted the system of taking the lime out after ventilation, turning it over, and putting it into the purifier a second time. He had continued this system for about four or five years, and the effect had been that he now purified the gas resulting from 27 to 30 tons of coal per yard of lime, and the lime when in operation the second time did nearly as much work as the first. He worked two purifiers, alternately using clean lime in one and once-used lime in the other. That which had been used twice went to the waste heap.

Mr. G. Anderson (London) asked at what rate the gas passed through the lime.

Mr. Harris said it varied in summer and winter, but the same thing took place continually. At the present moment they were passing a million cubic feet of gas per day through two purifiers in succession each about 26 feet square.

Mr. J. Eldridge (Richmond) asked if there was any great nuisance in using the lime a second time.

Mr. Harris said practically they had no nuisance at all. The lime was perfectly innocuous when taken from the purifiers by both the first and the second time.

Mr. W. W. Hutchinson (Barnsley) said there was some information given at the last meeting of the Manchester District Institution of Gas Engineers which might throw light on the subject of the sulphur deposits. At Wigan there was in use a process of drawing a certain quantity of air through the lime purifiers in order to revivify the lime; and he was informed that they passed 10 million cubic feet of gas through one purifier, 12 feet square, without its being opened at all. He was not, however, informed as to the particular quantity of sulphur or bisulphide of carbon which existed in the gas, though it was interesting to know that there was no nuisance caused by it.

Mr. G. R. Hislop (Paisley) said he had given this matter considerable attention for 6 or 7 years. The mode he adopted for the lime was simply to work it alternately with the oxide of iron, the foul gas entering the oxide first and then the lime, and alternately entering the lime first and secondly the oxide. In this way they fulfilled all the requirements and conditions laid down by Mr. R. H. Patterson in forming sulphide of calcium in order to remove the bisulphide of carbon in the gas. When oxide of iron was not employed along with lime, he preferred drawing the carbonic acid gases from the furnaces, of which they had any quantity, through a suitable condenser, and driving it up through the foul lime in the purifier before it was disturbed; otherwise, if it were broken up, the gas would not reach every atom of lime in the purifiers. But passing the carbonic acid gas through the lime undisturbed, it would follow the channels previously taken by the coal gas, and, therefore, reach every atom of lime, and discharge the whole of the sulphuretted hydrogen into oxide of iron contained in a separate tank or old purifier. The period when this was accomplished was ascertained in a very simple way by the acetate of lead test. When this test failed, the process was stopped and the lime taken out, which was found perfectly innocuous, and transferred to the calcining chambers. In connection with the first arrangement of working the lime and oxide alternately, he had restored the lime 150 times over, and if any gentleman saw it he would scarcely observe any difference in its appearance from the first day it was introduced into the purifier. The process was, therefore, reduced to the simplest possible form. It was worked in the ordinary method, avoiding any nuisance, and the objectionable substance was got rid of in a very profitable way. The cost was 7s. 6d. to 8s. per ton according to the locality and quality of the fuel employed. He was not quite sure as to the process suggested, of passing air through the lime, fearing the sulphur would be so far fixed, in other words that a chemical action would be set up and intense heat generated, and the sulphur fixed in the lime. In his way of treating it, the life of the lime was very much lengthened by the use of carbonic acid; it was maintained perfectly cool until the whole of the sulphur was discharged, and then nearly pure carbonate of lime was obtained.

Mr. Corbet Woodall asked if any explanation could be given, beyond that already afforded by Mr. Foster, of the reason why the lime removed from the purifier and then exposed to the action of the atmosphere, if there were no chemical alteration in its constitution, should be operative for the removal of bisulphide of carbon upon which before it had no effect. He thought he must have misunderstood Mr. Foster, but he gathered that the lime as removed contained no calcium hydrate. He thought this must be a mistake, as he subsequently dealt with the quantity remaining in the purifier. He should like also to ask whether any attempt had been made to use the lime a third time, and, if so, what had been the effect.

Mr. ELDRIDGE said he gathered that Mr. Hislop was using lime and oxide alternately; but how would this answer with regard to taking out the bisulphide of carbon? It would be all right as far as restoring the lime was concerned; but how would it be with regard to the bisulphide of carbon, if they were compelled to keep down the sulphur to 20 grains per 100 feet of gas?

Mr. W. CARR (Halifax) said the paper opened up a large subject of inquiry, and after the explanation they had the previous evening of what had been made of the once despised coal tar—when they heard of so many different compounds being produced from it—they might hope that eventually something might be made of spent lime. It did seem quite possible that some day it might be used either as a valuable manure, or for other purposes. With reference to the lime from Mr. Harris's process, his idea was, as it was said that exposing it to the atmosphere did not produce any chemical action upon it, that it was pulverized, and made more accessible to the gas—that a quantity of hydrate of lime still remained, after it had been in the vessel some time, which had not been touched. This opened up a question that was pretty well discussed a few years ago, whether lime pulverized or in nodules was best for purifying. It was then asserted very forcibly, and not contradicted at the time, that the lime was better by being prepared in the shape of nodules. He did not know whether this was correct or not, and had never been able to test it for himself. He had to take it, like many other things, on credit. He knew it was much better to work in this way where there were small purifiers, because the gas passed more completely through it; but still it might be that a great quantity of lime was wasted by this process, and if it led to the investigation of that point alone the paper would be very useful.

Mr. FOSTER, in reply, said with reference to the amount of caustic lime in the partially spent lime, he determined this by means of the copper chloride reaction. The sample still contained 21 per cent., so that there was a great amount of work still to be got out of this particular specimen. The question of the free sulphur was the most interesting. He had gone into the details of the behaviour of each of the three compounds independently, and so far there was nothing to report which would explain the formation of free sulphur in the alkaline condition of the mixture. Many of those present were, no doubt, aware of the processes adopted for the recovery of sulphur from soda waste. These were processes of atmospheric oxidation, which brought the sulphur to a certain condition, a certain relative proportion of sulphur in a given condition, and a certain proportion in another—the two must stand in a certain ratio. Then, by the action of acids on the exposed soda liquor, free sulphur was thrown down. But there was nothing of this kind, so far as he could see, in the exposure of spent lime. It was exposed to the air and remained alkaline, and this was why he said there was something which was not intelligible, by the aid of their experience, as to the behaviour of each of the three compounds independently. Mr. Harris agreed with him that it was quite possible there might be other sulphur compounds beside bisulphide of carbon in coal gas. Mr. Harris found that he could take out a certain quantity of sulphur in the form of sulphur compounds by means of lime (the gas passing at a certain rate) with no effect on the other portion. He argued from this circumstance that the sulphur compounds were not all in the same condition, as they were not all so easily removed. One might oppose this theory by saying that the tension of the carbon bisulphide was considerably changed by an alteration of temperature, and this might modify the chemical affinity of the sulphide of calcium upon the sulphur compounds. There were many ways of looking at the question. Most probably there were carbon-sulphur compounds other than bisulphide of carbon present. Mr. Hislop would not like to expose the lime as Mr. Harris did without a power of fixing the sulphur; but the curious part of it was that the sulphur seemed to be largely eliminated in the form of free sulphur. He was furnished with a sample of gas-lime which had not been exposed to air; but, his time being limited, he had not been able as yet to touch it. Besides, it was very difficult to determine the actual condition of the sulphur in its very varied forms. One point he should like to know was the condition of the lime as it left the purifiers without atmospheric oxidation. This was the link missing in the evidence he had given. He had tried to afford an explanation of the effect brought about by exposure, from the particulars furnished by Mr. Harris. He did not regard it as due to chemical action at all, but to mechanical splitting up of the particles, so as to render the lime available for further treatment, though this might not be the correct view of the matter. It seemed to be a possible explanation when there was something still missing. With reference to the question as to the amount of caustic lime remaining, there was 21 per cent.

The PRESIDENT said the paper was a very valuable contribution to the Transactions of the Association. It and the discussion which followed had suggested the possibility of their being able to revivify lime in much the same way, although not, of course, to anything like the same extent as they now revivified oxide of iron. Any process by which they could effect a reduction in the original weight of lime employed must be of great value, considering the almost intolerable nuisance occasioned, and the difficulty of getting rid of spent lime in many localities. Mr. Foster, therefore, deserved their best thanks for having brought this subject forward.

METROPOLIS WATER SUPPLY.

METROPOLITAN BOARD OF WORKS.

At the Meeting of the Board last Friday, the Parliamentary Committee presented the following report, which was agreed to:—

"The Board, on the 28th ult., referred it to your Committee, as well as to the Works and General Purposes Committee, to take such steps as might be necessary to enable the Board to assist in any inquiry concerning the Supply of Water to the Metropolis. The Board at the same time directed that certain Counsel should be retained, and these gentlemen are now appearing at the inquiry on behalf of the Board.

"It occurred to your Committee that the investigation might show the expediency of the Board taking some further action on behalf of the ratepayers beyond merely assisting in the inquiry. It might, for instance, seem expedient that the Board should make some application to Parliament on the subject next session, or take part in some measure which might be otherwise introduced. Unless, however, the Board's powers under the 144th section of the Metropolis Local Management Act were enlarged, it would be impossible for it legally to take such action. Your Committee felt that for the Board to take a useful part in this investigation and in any further proceedings which might be necessary, its power to do so ought to be clearly established. A letter was accordingly addressed by their direction to the Secretary of State for the Home Department, asking him to introduce a Bill into the House of Commons with a view to its becoming law during the present session, to extend the operation of the 144th section of the Act above mentioned, so as to enable the Board to make any application to Parliament which might be necessary with reference to the Water Supply of the Metropolis, or to appear upon any application which might be made to Parliament on the subject. To this letter a reply, dated June 19, has been received from the Home Office, to the effect that the Government will be glad to give all the facilities it can in the matter, and asking that a draft of the Bill which the Board proposes may be submitted to the Secretary of State.

"Before proceeding further in the matter, your Committee think it desirable to obtain the sanction of the Board to what is proposed. They accordingly recommend that the Solicitor be instructed to prepare a draft Bill to the effect above suggested, and that the draft Bill, when approved, be sent to the Home Office, with a request that the Secretary of State will himself introduce it into the House of Commons."

The following is Dr. Frankland's report on his analyses of the water supplied to London during May:—"Taking the average amount of organic impurity contained in a given volume of the Kent Company's water during the nine years ending December, 1876, as unity, the proportional amount contained in an equal volume of water supplied by each of the Metropolitan Water Companies, and by the Tottenham Local Board of Health, was—Colne Valley, 1·4; Kent, 1·5; Tottenham, 1·7; Grand Junction, 2·4; East London, 2·7; New River, 3·3; West Middlesex, 3·3; Chelsea, 3·7; Lambeth, 4·4; Southwark, 4·8. The Thames water delivered by the Grand Junction and Chelsea Companies was, for river water, of fairly good quality, but the West Middlesex Company's water was slightly turbid from inefficient filtration; whilst that distributed by the Southwark and Lambeth Companies, though obtained from the same source, was much more polluted by soluble organic matter. The Southwark Company's water was also slightly turbid from inefficient filtration. The Lea water, delivered by the New River and East London Companies, was efficiently filtered, and of about the same quality as the better samples of Thames Water. The deep-well water supplied by the Kent and Colne Valley Companies and by the Tottenham Local Board of Health was of its usual excellent quality for dietetic purposes, and that sent out by the Colne Valley Company was suitable for all domestic purposes, having been softened before delivery."

Results of Analyses expressed in Parts per 100,000.

Companies or Local Authorities.	Total Solid Matters.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen, as Nitrates and Nitrites.	Total combined Nitrogen.	Chlorine.	Total Hardness.
Inner Circle.								
Thames—								
Chelsea	25·00	·172	·044	0	·199	·243	1·5	19·1
West Middlesex	25·70	·153	·043	0	·194	·237	1·5	19·1
Southwark	25·76	·227	·054	0	·205	·269	1·5	19·4
Grand Junction	25·30	·102	·038	0	·182	·220	1·5	19·4
Lambeth	26·32	·215	·047	0	·201	·248	1·5	19·6
Lea—								
New River	24·34	·166	·028	0	·192	·220	1·6	19·4
East London	24·62	·121	·039	0	·126	·169	1·8	19·4
Deep wells—Kent	42·23	·076	·013	0	·382	·395	2·5	26·0
Outer Circle.								
Colne Valley	12·94	·066	·016	·003	·346	·365	1·5	4·9
Tottenham Local Board	40·20	·087	·018	·046	·025	·081	2·9	20·8
Corporation of Birmingham*	21·96	·128	·030	·004	·264	·297	1·8	13·7
Corporation of Glasgow+	3·02	·115	·016	0	·006	·022	·61	·9

* Analyzed by Dr. Alfred Hill, Medical Officer of Health and Analyst to the Borough.
+ Analyzed by Dr. E. J. Mills, F.R.S., of Anderson's College, Glasgow.

Note.—The numbers in the analytical table can be converted into grains per imperial gallon by multiplying them by seven, and then moving the decimal point one place to the left. The same operation transforms the hardness in the table into degrees of hardness on Clark's scale.

SOME NOTES FROM AMERICA.

(FROM OUR OWN CORRESPONDENT.)

Gas affairs in the Metropolis are in about the same position as at the time of my last letter [see *ante*, p. 801.] A Committee, appointed by the Municipal Gas Consumers Protective Association, waited on that Company last month, and presented their alleged grievance—viz., the high price of gas; or, more correctly, the raising of the price back to the old figure of 2 dols. 25 cents per 1000 feet. Having had a taste of the pleasure of getting gas at an inordinately low figure, while the several Gas Companies were engaged in cutting each other's throats, they are very unwilling to have to submit to paying the old price. The Committee were courteously received by the officers of the Company, but as their chief officer, the President, was away, the Company put them off with the understanding that their petition would receive attention, immediately upon the return of that gentleman. There the matter rests, and we here patiently await the sequel.

In the meanwhile, the death of a gentleman connected with the Municipal Company, and widely known as an inventor and a chemist, has occurred. I allude to the death of M. Cyprien Tessié du Motay, which occurred on Sunday, the 6th inst. This distinguished gentleman was born 65 years ago, of an old and aristocratic family. He began the study of chemistry in Germany, when he was about 25 years of age. He was the originator of a great many improvements in various manufacturing processes, which have been of great service to mankind, and have given to his name a world-wide reputation. He was, however, a public man as well as an inventor,—an ardent Liberal and a Radical Republican; the free expressing of his Liberal opinions, securing for him, under the Bonaparte dynasty, the sentence of death. His great scientific attainments then stood him in good stead, for not only was the sentence of death commuted to one of exile, but later he was allowed to return to Paris, where he continued his researches in chemistry. He then turned his attention to gas lighting, and took out several patents relating to that subject. Mr. Stern, of New York, bought of M. Du Motay his "water gas" patent. Latterly M. Du Motay had been filling the position of Consulting Chemist to the Municipal Gas Company of New York. His death, which occurred in New York City, was due to apoplexy. His remains will be sent to France for burial.

The inquest in the case of James Rolleter, an *employé* of the New York Gas Company, who was killed by an explosion at those works—which I noticed in my last letter—was concluded on the 20th ult. One witness, an *employé* of the Manhattan Gas Company of the same city, testified to seeing a man with a lighted match in his hand, on the stairs inside the purifying building just before the explosion; but it does not seem possible that any sane man would light a match in such a place. The jury returned the following verdict:—"The jury unanimously agree that the death of James Rolleter was caused by injuries resulting from an explosion at the New York Gas-Works, and that the testimony adduced indicates that the Company are at fault, inasmuch as the explosion would not have occurred had proper supervision, management, and caution been enforced by it in the conduct of operations within the building where he (the deceased) was working at the time of the accident." So, taking it for granted that the testimony was correct, the Company are blamed for the folly of one of their servants.

It does not seem that a great deal is being done in this country with the electric light; in fact, the subject seems about where it was a year ago. Some few factories have introduced the Brush machines in place of gas, thus cutting off a little of the revenue of the gas companies; but, as yet, this is a small matter, and I trust it will remain so. What the companies have lost by the electric light they have more than made up in extending the use of gas for other than lighting purposes. Here is a field for almost all gas companies, and, if they will only take a little trouble, they may occupy it, to the increase of their general prosperity. It is continually said that a factory can employ the electric light advantageously, because they can use their "surplus motive power" to drive the machines. One word in regard to the term "surplus motive power." What do manufactories have such surplus power for? I take it that the object is never to run their boilers and engines to their full capacity, for it is poor economy to get out of any motor the last pound of power it is capable of exerting. If, then, the great part of this surplus power is used in generating the electric light, is it fair, when figuring the cost of the light in factories, to leave out altogether the cost of motive power? I think not. In some large factories, where they have a great abundance of power, that used by the generators of the electric light may be a small matter; but in other places it may be an important factor, and necessitate an increase of power. In either case, some allowance should be made for power to drive the generators when estimating the cost of the light produced by them. Apparently, Edison is doing nothing in his pet scheme of annihilating the gas companies; but, while on the surface it appears as if he has given his attention to other matters, on the other hand, there is a quiet, underground rumour that he is bringing his apparatus rapidly to perfection. Some people are bold enough to say that this time there is no doubt of it at all—that success is almost certain. We can, however, patiently await his pleasure. I have always contended, and will continue to hold to it, that such a great industry as gas lighting will not have so short a life as some insist, but that, as it is the light of the present, so it will continue to be not only the light, but the heating, and in some degree the motive power of the future.

A new stoking machine has been brought out in this country—the invention of Mr. Ross, of Cincinnati. In the absence of sectional drawings, I will not, at this time, enter into a detailed explanation of the machine, but will notice its chief novelty. This is in the charging machine, where the coal, instead of being carried into the retort by a scoop, and laid upon the floor of the retort, is thrown up or projected in by the direct action of steam. Coal of the usual size is received into a hopper, and thence passes into a conduit, adjusted to the level of the retort, and steam is admitted, through nozzles at the back of the coal, by sudden openings of the steam-valve. The coal is thus projected into the retort. The questions naturally arise whether the coal will not strike the end of the retort with sufficient force to injure it, as force enough is used to ensure its reaching the back of the retort; and, secondly, what effect will the admission of so much steam into the retort have upon the gas?—whether it may not be more difficult to keep up the heats. At present each charging and drawing machine is on a separate carriage, having thereon a boiler, supply-tank for water, steam-chest, &c., besides the regular apparatus. It would seem as if this expense might be obviated by having each apparatus connected by a flexible pipe with a permanent steam supply.

During last month two deaths occurred in different hotels in New York, through escapes of gas. In each case the cock of the gas-fixture was turned on full, and the occupant of the room dead.

P.S.—Since closing my letter, news of a meeting of the Municipal Gas Consumers Protective Association held last evening [June 8] has reached me. The Committee appointed to wait on the Company reported that they had been given to understand that the Company would not reduce the price of gas. A motion asking all the consumers of the Municipal Company's gas to discontinue dealings with the Company was passed. They wish to have the price reduced from 2 dols. 25 cents. (9s.) to 1 dol. 50 cents (6s.)

THE LANCASHIRE COAL AND IRON TRADES.

(FROM OUR OWN CORRESPONDENT.)

All classes of round coal are now more or less a drug in this district, whilst prices throughout are so low—in some cases under the actual cost of getting—and there is so little prospect of the demand overtaking the means of production for some time to come, that colliery proprietors do not care to raise coal for stock, as is usually done at this season of the year. The consequence is, that short time is being enforced at nearly all the Lancashire collieries, a very large number of them not running more than five or six days a fortnight.

As yet there have been very few gas coal contracts settled; but it is probable that a considerable number will be concluded during July. Very low tenders continue to be sent in, gas coal, I believe, being delivered into Manchester at 7s. 6d. per ton, whilst there are plenty of sellers of good screened Wigan gas coal at the pit at 5s. 9d. to 6s. per ton. Tenders for long periods are also offered freely, and those firms who are not prepared to contract for something like three years have very little chance.

In other classes of coal the tendency of prices is downwards. House coals are now very bad to sell, and the Manchester firms are making reductions of 10d. and 1s. 8d. per ton in their delivery rates to private consumers. In pit prices there is no announced alteration, but generally there is a weaker tone, concessions being made to secure business. Best Wigan Arley at the pit does not, for quantities, fetch more than 7s. 6d. to 8s.; whilst common sorts and Pemberton four-feet can be bought under 6s. up to 6s. 6d. per ton. Common classes of round coal for steam and forge purposes are being offered at extremely low figures, ranging in many cases as low as 4s. 6d. per ton at the pit. Engine classes of fuel continue in fair demand, and although there is no actual scarcity of supplies at present, there is less being produced, and in some cases an attempt is made to obtain higher prices; from 3s. 9d. to 4s. 3d. per ton being about the average quotations for good burgy at the pit, and 3s. 3d. to 3s. 9d. for good slack.

The shipping trade continues very dull, and Lancashire steam coal delivered at Liverpool or Garston can be bought at 6s. per ton.

The limited demand for coke is causing many of the ovens to be put out, but prices nominally are without change, although there is an easier tone in the market.

There is a slightly better feeling in the iron trade, and although consumers are purchasing very sparingly, there is more disposition to buy; whilst some considerable sales of outside brands for forward delivery have recently been made to middle-men in this district. Lancashire makers of pig iron have been doing a little more business, but a good deal of iron is still going into store, with quotations nominally remaining at 47s. 6d. per ton, less 2½ for delivery into the Manchester district, although less would be taken if offers were made. In some quarters a few more inquiries are reported for finished iron; but makers, as a rule, are pressing for business at very low figures, and Lancashire bars delivered into Manchester can be bought at from £6 to £6 10s. per ton, if not under.

THE SOUTH STAFFORDSHIRE COAL AND IRON TRADES.

(FROM OUR OWN CORRESPONDENT.)

In one or two cases local pits of which the output has been mostly consumed by the blast furnace have lately been idle, or at least have been employed only one or two days in the week. This is an inevitable consequence of the decline of the pig-making business. As the lowest ebb has not yet been reached, judging by the continuation of the operations of blowing out, the smelting coal trade is in a very bad state. The deep pits, however, are much better off, and the demand for thick coal is fairly good, though scarcely so great as it was a month ago. Prices for best qualities are firm, but of inferior kinds they are in an unsettled state, and are anything but uniform. Gas coals, engine coals, and slack, are, on the whole, in fair request. In the Tipton district the competition is very keen with the small colliery proprietors.

The iron trade has shown but little alteration; there was, however, during the past week, a better call for all kinds of finished iron at the usual weekly markets, and most classes of pigs were firmer than they have been for a few weeks past. The only increased rates noted were for special brands of merchant iron, but unmarked bars are not so freely offered, and though some parcels changed hands at prices below £6 10s., several lots were placed at £6 15s. Best marked bars are offered at £8, though it is considered that probably £8 10s. will be the rate fixed for them at the approaching quarterly meeting. Sheets (common singles) are to be had at £7 15s.; but girder plates are scarce at £9 10s. All-mine is quoted at £4, which is a little over last week's prices. Part-mine stands at £2 15s. to £3, and cinder pigs at about £2. It was considered probable that the reduction of 10 per cent. in furnace-men's wages, which came into operation a week ago, would cause some slight reduction further than was shown in the previous week's markets; but there is now, on the other hand, a somewhat firmer tone. The inconvenience sustained by the iron trade in the matter of weights as now used in accordance with the Weights and Measures Act of 1878, has been the subject of much controversy, and one of the local members asked the President of the Board of Trade in the House, on the 21st, to cause a standard weight of 112 lbs. to be denominated, but was unsuccessful in his efforts.

THE YORKSHIRE COAL AND IRON TRADES.

(FROM OUR OWN CORRESPONDENT.)

The tenders for further contracts for the supply of gas coal to Yorkshire gas companies continue to be placed, several having been decided since my last notice. It may be said that directors never had more quotations, nor was there ever more anxiety with respect to the placing of the contracts so far as coalowners are concerned. One of the companies received tenders from both the Barnsley thick-seam pits and those working the Silkstone bed. Prices are, if anything, lower than they were last year, some firms quoting Silkstones as low as the Barnsley bed.

During the past week great attention was paid to the decision of the Directors of the Railway Companies interested in the conveyance of coal to London, who were appealed to, but have declined to reduce the rates, which are now 8s. 3d. per ton, including City dues. It is understood that the Great Northern would have conceded something, but other interested Companies could not see their way clear to meet the coalowners. Some of the coal merchants in London went so far as to only ask for some concessions to relieve them during the present exceptional state of trade, but even this request was not granted. The demand for house coal is very quiet, not only as regards the Metropolis, but also the other markets with which the collieries are connected.

Steam coal is in good request for shipment, and large quantities continue to be forwarded to Hull and Grimsby, which has the effect of keeping the exports well up. The West Riding coalowners are doing a fair business with Goole, which port is within easy reach of the coal-field. The

pits in this district are, however, working but short time, and miners are complaining of earning low wages.

The coke trade, taken as a whole, holds well up, but the output is in excess of the demand, owing to the building of so large a number of new ovens. There is a large traffic over the Manchester, Sheffield, and Lincolnshire line for North Lincolnshire, but the trade in that district is on the decline, one of the firms having already damped down one of their furnaces; whilst the tonnage of pig iron from the furnaces is not nearly so large as it was a couple of months since.

The iron trade is not so cheering as it was a short time ago. The blast furnaces are kept in full work, but the foundries are only slack. The same may be said with regard to engineering branches, fitters, and machinists.

THE COAL AND GENERAL TRADES OF THE NORTH OF ENGLAND.

(FROM OUR OWN CORRESPONDENT.)

The gas coal trade of the county of Durham has been quiet over the past fortnight, having been of the usual summer character. It is very much limited to shipments to meet the ordinary contracts. Very little business has been done in gas coals in the open market, and no new trade has been taken in for later on in the year. A large amount of uncertainty surrounds the prospects of the general coal trade at this, the commencement of the second half of 1880. The steam and house coal businesses are undoubtedly dull. The coalowners in the first-mentioned trade have not been able to uphold their prices, which are about 6d. per ton lower than they were a month ago. Firms in the iron and chemical trades are unable to determine what will be the requirements of the next six months, as a very great amount of uncertainty surrounds the prospects of these trades over the period mentioned. The manufacturers are very slow to make contracts for small coals. Coke, in sympathy with the stronger tone in the pig iron trade, is a little dearer, the value being 11s. 6d. per ton, delivered free on board ship in the Tees.

The shipping trade, especially coasting, shows no improvement. Freights are low. There is no appearance of an advance in rates. Very little business is transacted in the way of freighting steamers or sailing vessels to load gas coals at present.

As the iron trade has a tendency towards improved prices, orders are coming into the foundries on the Tees and Tyne for gas and water pipes. The fall in pipes over the last half year has not been so rapid as pig iron; but as they are not affected by speculative movements, the rise is not so great, and prices do not advance to the same extent. There is, however, an opportunity at present to buy at a reasonable rate, and companies are tempted to secure supplies. The lead trade is better. Spanish ordinary lead is sold in the wholesale market on the Tyne at £15 17s. 6d. per ton, which is an advance of fully £1 per ton upon the prices which were current in the early part of June. The price of copper is also stronger. Indeed, metals of all descriptions show a slightly upward tendency. The shipments of the best sorts of fire-clay goods to the Continent are well sustained. Second-class kinds have somewhat fallen away in value.

TRADE NOTES FROM SCOTLAND.

(FROM OUR OWN CORRESPONDENT.)

The Directors of the Hawick Gaslight Company have just issued a most satisfactory report, which is to be considered at the annual general meeting of the Shareholders on the 2nd prox. Referring to the previous year's balance-sheet, which showed that the profits earned during that year were upwards of £400 short of the amount required for paying the guaranteed dividend of 10 per cent., they go on to say that, notwithstanding the reduction of 5d. per 1000 feet in the price of gas (amounting to upwards of £450), the profits made during the past year are more than sufficient to pay the guaranteed dividend. That such a favourable result has been attained is, they say, in a great measure due to the success of the experiments which were mentioned in last year's report as being carried out by the Manager (Mr. J. Smith). In order to have the means of accurately determining the illuminating power and the purity of the gas, and of testing the value of coals previous to making contracts, a new laboratory, furnished with the most improved instruments, has been fitted up, and has been in operation for some time. The illuminating power of the gas supplied to the consumers during the past year was maintained at 29 to 30 candles. Contracts for coals for the ensuing year have been made on favourable terms. New street-mains of fully a mile in length have been laid during the past year; the consumers have become more numerous, and the increase in the amount of gas sold was nearly a million cubic feet. Loss by condensation or leakage was moderate, and for each ton of coal delivered at the works 9030 feet of gas were sold. From May 26, 1879, till May 26, 1880, the gas sold amounted to nearly 23 million cubic feet, almost the whole of which was sold at 3s. 9d. per 1000 feet. The attention of the Shareholders is drawn in the report to the balance of £956 still remaining over, after the payment of the yearly dividend is provided for; and as the mode in which such balances are to be applied is regulated by the Company's contract of co-partnership, the Directors recommend that the price of gas for the ensuing year be fixed at 3s. 6½d. per 1000 cubic feet. That price will be subject, I believe, to a discount of 7½ per cent. to the large consumers, thereby making the net price to them 3s. 3¼d. per 1000 feet. Should the proposed price of 3s. 6½d. be agreed to at the annual meeting of the Shareholders, there is every probability that the question of "The Cheapest Gas in Scotland," which was discussed with such persistence and animation last summer and autumn, will be renewed. To be able to sell 29-candle gas at that price will certainly be regarded on many hands as a great achievement. Before the discussion is resumed, I may remind those persons who are likely to take part in it that the Company make a charge of 2s. 6d. per annum in the shape of meter-rents. Gas managers in Scotland scarcely need to be reminded that Hawick lies at a considerable distance from any mineral field were gas coal is worked.

The monthly meeting of the Perth Gas Commissioners was held on Monday, the 14th inst., Lord Provost Richardson in the chair. An abstract of the revenue and expenditure of the Commission for the year ending the 30th of April last was submitted. The revenue amounted to £13,124 13s. 2d., and the expenditure to £12,091 2s. 9d., and the sum of £1061 1s. 11½d. was set aside for the sinking-fund, and to meet contingencies. The expenditure for the current year was estimated at £12,497 10s., the sinking fund and contingencies at £710 3s. 4d., and the revenue at £13,207 13s. 4d. In moving the adoption of the balance-sheet and Auditor's report, along with the estimates for the current year, Bailie Mackenzie said that the year ending the 30th of April had been a very prosperous one for the Gas Commission. They had been able not only to pay off all the working expenses, but, besides laying aside £100, as had been estimated, towards the contingency and depreciation fund, they had been able to apportion £230 additional to meet the expenses of a new exhauster. The cost of this new exhauster was to be paid out of last year's revenue, and still there was £200 to add to the contingency and depreciation fund. The increased consumption of gas during the year had amounted to 2,744,630 cubic feet, or 2¾ millions increase over that of the year 1879. The actual increase in the consumption of gas since 1874, which was the first whole year the Commission had the works in their hands, was over 50 per cent. Having explained the method in which the finances of the Commission were conducted, Bailie Mackenzie concluded by moving the adoption of the balance-sheet and estimates, as also that the price be 4s. 2d. per 1000 cubic feet, with the usual meter charges for the city, and 5s. for Scone; and that the 5 per cent. discount be given to large consumers as usual. The motion was duly seconded and unanimously adopted. Including renewals and extensions, the piping laid during the past year amounted to about 2 miles, and the leakage is now reduced to 8·9 per cent.

At the annual general meeting of the Selkirk Gaslight Company, which was held a few days ago, a report was submitted which, along with the statement of the income and expenditure, showed that the affairs of the Company were in a prosperous state. A dividend of 10 per cent., free of income-tax, was declared, and it was agreed to reduce the price of gas for the ensuing year from 5s. to 4s. 7d. per 1000 cubic feet. The make of gas for the year was 14,340,900 feet, as indicated at the station-meter, and the unaccounted-for gas had been reduced to 10 per cent. Owing to dull trade in the town there was a decrease on the consumers meters of 563,000 cubic feet over the year.

During the year ending the 15th of June there was an increase in the amount of gas manufactured at the Forfar Corporation Gas-Works of 1,330,000 cubic feet over that manufactured in the preceding year; and for the year just commenced contracts have been closed for 2000 tons of coal at an average price of 18s. 11½d. per ton, whereas the average price last year was 20s. 5d. per ton, the reduction giving for the current year a saving of something like £150 on the cost of the coals required.

The annual general meeting of the Dunfermline Gaslight Company was held last Wednesday—Mr. David Russell, Chairman of the Company, presiding. Mr. Mackenzie (the Manager) read the report of the Directors, which stated that the quantity of gas sold during the past year considerably exceeded that of any preceding year, that the loss by leakage had been very much reduced, and that the illuminating power and purity of the gas were well maintained. A reduction in price to consumers—equal to 4 per cent.—had been in operation during the year, and the results of the whole year's working were in many respects satisfactory. Contracts for coal for the coming season were being made, and the Directors had every reason to expect that they would be concluded on favourable terms. The works and whole apparatus were in good order, and in the most efficient state of repair. On the recommendation of the Directors, a dividend of 29s. 9d. per share, being at the rate of 8½ per cent. per annum, was declared, and the report was unanimously adopted. In the course of the proceedings, the Manager reported that since the supply of gas had been extended to Townhill, the consumption there had gone on increasing, and he likewise stated that the greatest satisfaction prevailed in the village at the existing state of matters. Bailie Walker and Messrs. John Davie and Thomas Alexander, jun., were appointed Directors in the room of those who retired. A cordial vote of thanks was passed by the meeting to the Chairman and Directors for their attention to the Company's interests during the year, and a similar compliment was paid to the Manager. The question of further reducing the price of gas in Dunfermline will not be settled until the price is known in other eight towns, some in the East and others in the West of Scotland—the average price paid in those eight towns being that which the Dunfermline Gas Company will charge for the ensuing year.

On Monday of last week the Shareholders of the Muirkirk Gaslight Company held their annual meeting—the Chairman of the Company, Mr. C. Howatson, presiding. The usual dividend of 10 per cent. for the year ending the 21st ult. was declared, and it was agreed to continue the price of gas at 5s. per 1000 feet. With a view of providing for an extension of the works, it was resolved to increase the capital of the Company by the creation of 1000 new shares of £1 each.

On Wednesday last there were offered for sale in Glasgow 100 shares of the Coatbridge Gas Company's new stock, of which 80 were sold at £11 per share, and the remaining 20 at £11 5s. per share. They are £8 shares, fully called up.

By the activity which has marked the action of the Dundee Water Commissioners, the Newport water supply, which was cut off by the fall of the Tay Bridge on the 28th of December last, is about to be replaced from the Wormit stream, situated about two miles west of Newport. The reservoir on the Wormit Hill and a large portion of the main which served for the Lintrathen supply have been found quite serviceable for the temporary scheme. It is expected the water system will again be in complete operation by the 1st of July.

On Thursday last, at a meeting of the Finance Committee of the Dundee Water Commission, the estimate of the expenditure and revenue for the year from May 15, 1880, to May 15, 1881, was submitted. The total expenditure was given at £38,252 13s. 7d. The revenue was estimated at £38,516 13s. 4d., showing a margin of £263 19s. 9d. It is proposed to continue the assessment for domestic purposes at the former rate of 1s. 4d. per £1. The revenue is made up in the following manner:—Domestic rate, £18,666 13s. 4d.; public rate, 1d. per £1—£2750; and special rates, £17,850. For bad debts £750 is entered. The estimates will be submitted at the annual meeting of the Commission to be held on Thursday of the present week.

Edinburgh water annuities advanced in price last week from £152 to £153 per share.

Last week's Glasgow pig iron market was very irregular, and a large business was done. The price of warrants advanced almost to 50s. per ton on Wednesday, and at the close on Friday buyers were offering 48s. 4½d. cash.

The coal market is exceedingly depressed, and strikes, both actual and threatened, on account of very low wages, are giving much anxiety to the coalmasters.

REDUCTION IN THE PRICE OF GAS AT ST. HELEN'S.—It is stated that the Gas Committee of the St. Helen's Corporation at their last meeting came to the conclusion to reduce the price of gas from 3s. 9d. to 3s. 6d. per 1000 cubic feet. It will be remembered that when the disposal of the gas profits was lately before the Town Council, something like an assurance was given by the Chairman of the Committee that if the Council would consent to allow about £1200 of the profits to be carried to the borough fund, the interests of the gas consumers would receive the immediate attention of the Committee, and that a reduction in the price of gas might reasonably be expected. The Committee, it now appears, have lost no time in carrying out the promise then made, and the reduction of 3d. per 1000 feet will be gratifying news, especially to large consumers of gas.

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